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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

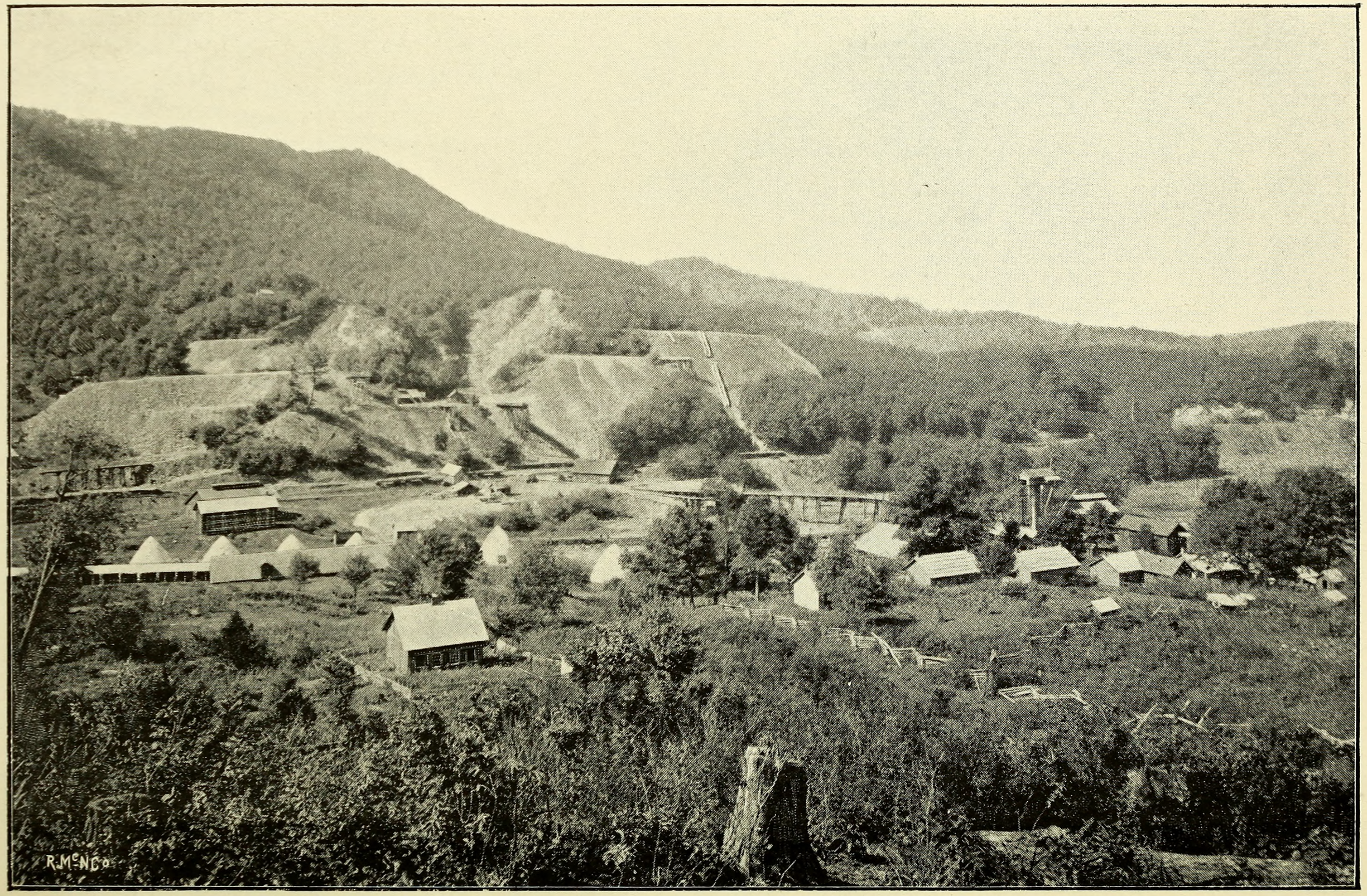
FIRST BIENNIAL REPORT

OF THE

STATE GEOLOGIST,

1891–'92.

RALEIGH:
JOSEPHUS DANIELS, STATE PRINTER AND BINDER.
1893.



THE CRANBERRY IRON MINE.

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CONTENTS.

PAGE.

LETTER OF TRANSMITTAL 7
REPORT OF THE STATE GEOLOGIST 9
  Introductory 9
  Objects and organization of the Survey 9
  Investigation of iron ores 10
  Investigation of building stone 11
  Geologic work in the coastal plain region 11
    Supplies of drinking water in eastern counties 13
  Examination of forests and forest products 14
  Investigation of mineral resources 16
  Coal and marble investigations with diamond drill 16
  Work of the State Geologist 17
  Miscellaneous work 18
    Topography 18
    Photography 18
    Collections for the Columbian Exposition 19
  Co-operation from the U. S. Geological Survey 19
  Chemical analyses and assay work 19
  Samples sent to the Survey for examination 20
  Relations of the Survey to private investment 21
  Expenses of the Geological Survey 21
  Future work of the Survey 22
  Some benefits resulting from the work 23
IRON ORES OF NORTH CAROLINA 25
NOTES ON BUILDING AND ORNAMENTAL STONE 59
  List of specimens of building and ornamental stone in the State Museum 105
Index 108

LIST OF ILLUSTRATIONS.

PAGE.

Plate I. Cranberry iron mine ... Frontispiece.
II. Map of Ore Hill, showing the relations of the iron ore deposits, etc. ... 32
III. Iron ore deposits, Stokes county ... 37
IV. Iron ore deposits of Gaston, Lincoln and Catawba counties ... 42
V. Map showing the location of iron ore belts, Ashe county ... 48
VI. Map of the Cranberry iron mine region ... 52
VII. Geologic map of North Carolina ... 63
VIII. Post-office building, Wilmington, of Wadesboro brownstone ... 66
IX. Post-office building at Raleigh, of Dunn's mountain granite ... 88
X. Mount Airy granite quarry, Surry county ... 94
XI. Mount Airy granite quarry, general view ... 94
XII. Shell-rock arch and wall, Newbern cemetery entrance ... 96

Fig. 1. Ideal section, showing lenticular structure and position of magnetite ore beds ... 42
2. Section along the Hiwassee river ... 55

BOARD OF MANAGERS.

Governor Thos. M. Holt, *ex officio Chairman*,	Raleigh.
Elias Carr,	Old Sparta.
J. Turner Morehead,	Leaksville.

GEOLOGICAL SURVEY STAFF.

J. A. Holmes,	State Geologist.
H. B. C. Nitze, Assistant Geologist,	Iron ores.
J. V. Lewis, Assistant,	Building materials.
W. W. Ashe, Assistant,	Forestry.
W. L. Spoon, Assistant,	Diamond drill borings.
H. L. Harris,	Sec'y and Gen'l Assistant.

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,
Raleigh, N. C., January 1, 1893.

To his Excellency, Governor Thos. M. Holt:

Sir:—I have the honor to submit herewith the first biennial report of the existing Geological Survey of North Carolina. It embraces, in addition to the administrative statement, an outline of the results of the work done during the years 1891 and 1892 in relation to iron ores and building stone.

The more extended statements of the results of the work will be published in special reports or bulletins as rapidly as these can be prepared.

In view of the fact that the mineral resources of the western counties of the State were at the time attracting more attention, and that they were the only ones of which topographical maps existed, the field work of the survey was begun in these counties. In this region, however, the geological structure, which had never been carefully examined, was found to be exceedingly complex, and this fact and the many difficulties encountered in the beginning of a work of this kind have combined to retard the progress made and limit the results accomplished by the Survey.

The benefits resulting from the work of a Geological Survey are never fully realized until years after the work has been completed and the reports published; but it is encouraging to note that even thus early in its history the present Survey has been instrumental in bringing to the State returns many times greater than its cost.

I beg, in conclusion, to express my appreciation of the active interest you have always shown in the work of the Survey and the wise counsel you have contributed to its management.

With great respect I have the honor to be, sir,

Yours obediently,

J. A. Holmes,
State Geologist.

FIRST BIENNIAL REPORT OF THE NORTH CAROLINA GEOLOGICAL SURVEY.

By J. A. Holmes, State Geologist.

INTRODUCTORY.

The existing Geological Survey of North Carolina was authorized by an act of the General Assembly of 1891. The writer received his commission as State Geologist on May 1st of that year; and the field work of the Survey began in June following in the north-western counties of the State. In view of the complexity of the geological structure in western North Carolina and the difficulties attending the inauguration of a work of this character, it will be readily understood that in the beginning progress was necessarily slow, and no elaborate reports can yet be prepared. The present report is not intended to include more than a general administrative statement, to which is added a summary of the results of the work of the Survey in relation to iron ores and building stone. It will be followed by other special reports or bulletins which will embody fuller statements of these results and which will be published from time to time as the *data* for them accumulates.

OBJECTS AND ORGANIZATION OF THE SURVEY.

The object for which the Survey was established, as expressed in the authorizing act, is "the thorough examination of the nature and extent of the mineral and timber resources of the State." The accomplishment of this object has been kept steadily in view in the organization and in all of the plans for the work of the Survey.

After a careful consideration of the work accomplished by preceding Geological Surveys in the State—under Emmons and Kerr—

the results from both of these having been lost in large measure by not having been published, it was found that a considerable amount of general exploration would be necessary in many portions of the State before undertaking, or in connection with, the examinations of special mineral deposits. And during the past two years a considerable portion of the time has been devoted to such *reconnoisance* work and preliminary investigations.

In connection with and in addition to this general work the following special subjects have been investigated by different persons connected with the Survey:

Iron ores, by H. B. C. Nitze.
Building materials, by J. A. Holmes and J. V. Lewis.
Geology of the coastal plain region, by J. A. Holmes.
Forests and forest products, by W. W. Ashe.
General mineral resources, by S. L. Penfield and others.
Coal and marble, diamond-drill borings, by W. L. Spoon.

INVESTIGATION OF IRON ORES.

The investigation of the iron ore deposits in the State was assigned to Mr. H. B. C. Nitze, a graduate of the mining school at Lehigh University, who has had a considerable amount of experience in the examination of iron deposits in several adjacent States. Mr. Nitze was appointed Assistant Geologist in June, 1891, and at once began an examination of the iron ore deposits of Ashe, Alleghany and Watauga counties, and remained in these counties during the remainder of the field season of that year. During the summer months he was assisted by Mr. H. L. Harris.

During the field season of 1892 he examined the more important iron deposits in all the other counties of the State where such deposits occur, extending his investigations over a territory of some 6,000 square miles in area, distributed through twenty-three counties.

During this examination some valuable iron ore deposits were discovered, and a number of other deposits were shown to have a value considerably greater than was formerly supposed.

At the end of this report will be found a statement by Mr. Nitze, embodying the more important results of his work during the years 1891–1892. A more elaborate statement is also to be published in the form of a separate bulletin (No. 1).

INVESTIGATION OF BUILDING STONE.

The investigation of the building stone deposits in the State was begun by the writer as soon as the Survey was organized, and has been continued by him at intervals until the present date. Mr. J. V. Lewis, a graduate of the University of North Carolina, and an assistant in the United States Geological Survey in 1891, was, in October of that year, appointed on the State Survey as an assistant in the building stone investigation, and continued in this position until October, 1892, when he was granted a leave of absence. During these two years (1891 and 1892) a preliminary examination of the building stone deposits was made in thirty counties, lying mainly in the midland and piedmont regions, but including Craven county in the east and Cherokee and Buncombe of the extreme west.

Many analyses and tests of the physical characters of the building stone of different regions have yet to be made before a more extended report on this subject can be published. But it is expected that a bulletin, embodying the results obtained up to date, will be published in the near future. The statement to be found further on in the present report, prepared mainly by Mr. Lewis, contains a *resume* of the results thus far obtained of the field exploration.

GEOLOGIC WORK IN THE COASTAL PLAIN REGION.

The eastern counties of the State grouped together occupy the territory here designated as the Coastal Plain region. This region has an area of about twenty thousand square miles, lying east of an irregular line from Gaston by way of Raleigh to Wadesboro. The geological formations of this region, consisting mainly of horizontally bedded and unconsolidated sands, clays, loams and marls, are radically different both in character and in age from those found in the middle and western counties of the State, which are composed mainly of highly crystalline, folded, diked, faulted and eroded schists, gneisses and granite. (See plate VII).

The examination of this region has been carried on during the past two years by the State Geologist at such times as could be spared from the work in the office and other investigations in the western and middle counties. The objects of this investigation have been the examination into the history and the character of the geologic formations; the occurrence in them of economic materials, such as phosphate, limestones and marls, and of deep lying water-bearing sands and gravels; and the origin and character of the soils, together with an examination of the character and distribution of the forest growth on these soils in different portions of the region.

In the prosecution of these investigations trips have been made down each of the principal rivers in small boats, so that the formations could be examined in the bluffs exposed along the line of the rivers; and at intervals overland trips have been made either on foot or on horseback across the country between the rivers. The examinations of the forests will be carried on more especially by Mr. W. W. Ashe, who will make extended trips on horseback through the different portions of the several counties of this region.

The general results of these investigations in the coastal plain region will be published in a special report at an early date; and the result of the forest investigations will be published in a Survey bulletin to be prepared by Mr. Ashe. Among the general results of the work which may be stated at this time are the finding of limited deposits of phosphate and more extensive deposits of limestone in several of the south-eastern counties; the finding of layers of water-bearing gravel and sand which are sufficiently deep below the surface to be free from a contamination of surface waters, and which consequently may be safely tapped by deep borings for a supply of drinking water in many portions of these eastern counties.

In examining the soils of these sandy regions we have found that many of these soils where the "waste lands" are rapidly increasing in area, owing to the cutting and burning off of the forests, are well adapted to the cultivation of various fruits, and may for this purpose be found to yield satisfactory returns for the labor which may be bestowed upon them. We have also found that in this sand-hill country, where already the "waste lands" amount to half a million acres, over considerable portions of this area there remain a sufficient number of long-leaf pines the seeds from which would be sufficient to restock these regions with young pine trees of this species if the areas could be protected from the ravages of forest fires and hogs.

SUPPLIES OF DRINKING WATER IN EASTERN COUNTIES.

The supplies of good drinking water in many portions of this eastern region is a matter of great importance to every person living in the region, and to this subject will be devoted one of the special bulletins of the Survey to be published in the near future. Indeed, this is an important problem for all sections of the State, whether thickly or sparsely populated. A large majority of our people use as drinking water that which comes from springs or shallow wells; and under favorable conditions water derived from these sources may be considered fairly safe for drinking purposes; but it should always be borne in mind that water from both these sources is, as a rule, of surface origin, and generally that it falls as rain water in the vicinity of the spring or well, soaks downward through the surface soil, carrying with it more or less of the impurities of the soil, and either comes to the surface again at some lower point as spring water or soaks into the sides of wells dug or bored to varying depths in the soil.

Considered in this light it will be readily understood that impurities of various kinds may reach the water which we drink not only by being washed into the open top of a well from the surface, or into a spring, but that they may soak down through the porous soil at a considerable distance from either spring or well, and yet permeate the drinking water by soaking through the soil of the immediate vicinity. And while these facts apply to all portions of the State they are especially applicable to these eastern counties of the coastal plain region. Here the drainage of the entire surface is less perfect than in the hill country, and stagnant surface water is far more abundant. The constant supplies of water are nearer to the surface, and at the same time, as the soils are more porous, the rain water soaks into them and down through the upper layers more rapidly and more abundantly than is the case in the hill country. And the result of these conditions is that waste matters which may lie on the surface soil in the fields or about the houses, and the germs which may accompany the decay of organic matter at the surface, may be carried down occasionally through the upper layers of the porous soil into the springs and wells which furnish the supplies of drinking water for this region.

From the result of inquiries now being made by the active Secretary of the State Board of Health, as well as those made by the writer, it is evident that this surface contamination of the drinking waters is probably the greatest source of the malaria prevailing in these counties; and it matters not whether the wells in this region be large open wells or the small bored wells; the impurities from the surface may soak down through the soil into the one almost as easily as into the other, because these impurities reach the water not so much by being washed into the open top but by soaking down into the sand and gravel which are the sources of the water supply.

It is for this reason that the Geological Survey has undertaken to investigate the possibility of supplies of drinking water at depths below the surface sufficient to be beyond the reach of such local surface contaminations. And it has found that in many if not in all portions of this region while the surface soils are usually loose and porous and below them, at depths varying from 10 to 30 feet, occur the water-bearing gravels, below these gravels occur the clay and the marls, and below the clay and the marls, at depths varying from 50 to 300 feet or more from the surface, there are other layers of sand and gravel which furnish ample supplies of water. And this water when it can be obtained should be fairly free from injurious matters because of the fact that the intervening clays prevent the surface water of the immediate vicinity from passing down into these lower layers of sand and gravel. In some cases, as shown by the borings at Franklin, Va., in Hyde county, and at Wilmington, in North Carolina, this deep supply of water when tapped by a pipe will rise to the surface of its own accord; and in other cases it comes sufficiently near the surface to be reached by pumps.

EXAMINATION OF THE FORESTS AND FOREST PRODUCTS.

In accordance with the requirement of the law establishing the Survey that it should investigate the timber as well as the mineral resources of the State, Mr. W. W. Ashe, who is a graduate of the University of North Carolina and of Cornell University, was appointed an assistant in charge of the timber investigations by the Survey in June, 1891. Portions of that year and 1892 he devoted to an examination of the character and distribution of the forests of the counties west of the Blue Ridge, and during the atter part of 1892 he began an examination of the forests of the middle and eastern counties, in connection with the collection of timber exhibits for the Columbian Exposition.

A report embodying the result of his examinations in the eastern counties will be ready for publication at an early date, and he will subsequently prepare for publication reports on the forests of the middle and western counties. A report including a description of the characteristics and the distribution of the more valuable forest trees of the State will also soon be prepared for publication by Mr. Gifford Pinchot, whose studies in forest management have been carried on in different parts of Europe as well as in the United States, and whose practical work in forestry has been carried on largely in western North Carolina. Mr. Pinchot is preparing this report without charge for his services. It will no doubt be a valuable contribution to the literature on the subject.

The timber resources of North Carolina are now attracting a large amount of attention from capitalists in all portions of the country, and during the next few years large investments in forest lands will no doubt be made in the State, both in the western and in the eastern counties. Hence, it is important that these reports should be published so that not only capitalists outside may know something of the forest wealth of the State, but also that those who now own these forest lands may know something of their value and the importance of their being treated in such a way that in using the valuable timber now existing on them the young growth may be preserved in such a way as to prevent a destruction of the future forests while using those of the present. And in this connection it may be stated that it will be the policy of the Survey to publish from time to time in the future special bulletins on the management and preservation of the forests of the State, in order that the people who own these forests may be able while disposing of their supplies of timber now available to do so under such conditions as will best protect the young trees and shrubs from injury by the lumbermen and from the still more common and destructive injuries from the forest fires and stock ; and thus perpetuate the forest wealth of the State.

INVESTIGATION OF THE GENERAL MINERAL RESOURCES.

It is a generally acknowledged fact that North Carolina contains a large variety of minerals, many of which have an economic value. Desiring to secure a wider dissemination of facts concerning these minerals, soon after the organization of the State Survey a report on the character and distribution of the minerals in North Carolina was prepared for the Survey by Dr. F. A. Genth, who did this work without remuneration from the State, and this report has been published by the United States Geological Survey as Bulletin 74 of its series. Thus, without cost to the State, a large amount of information concerning its mineral resources has been published and widely disseminated. During the summer of 1892, Professor S. L. Penfield and Mr. Joseph H. Pratt, of the Sheffield Scientific School, Yale University, without remuneration for their services, investigated a large number of mineral deposits in the counties west of the Blue Ridge, especially in the mica mines of Yancey and Mitchell, and the chrysolite rocks and the associated chrome and corundum deposits in Watauga, Mitchell, Yancey, Jackson, Macon and Clay counties; and the results of these investigations will be embodied in a future bulletin to be published by the Survey.

COAL AND MARBLE INVESTIGATIONS WITH THE DIAMOND DRILL.

Early in 1891 the coal deposits near Walnut Cove, Stokes county, were attracting considerable attention, and it was considered advisable to investigate them. As this could not be satisfactorily done in any other way, the Survey rented a diamond drill from the Pennsylvania Diamond Drill Company, and placed the work under the supervision of Mr. W. L. Spoon, in July of that year, and the work was continued until May, 1892. Two holes were bored in this field, the deeper one going down about 1,112 feet, and no valuable bed of coal having been penetrated, the work was abandoned. This negative result does not necessarily indicate the absence of valuable deposits of coal from the entire Dan river sandstone belt, but it does indicate their absence in the particular rocks penetrated by these borings. And while the result in this case is a negative one and led to no additional investments of capital, it prevented the expenditure of considerable sums of money which would have been lost in proposed mining operations.

Near the south-western end of this sandsone belt, between Walnut Cove and Germantown, the indications of the existence of workable beds of coal are more favorable than those in other portions of the region, and here they are worthy of further investigations, but in the immediate vicinity of Walnut Cove, where the borings were made, I think the negative evidence may be accepted as final.

Early in the summer of 1892 the drill outfit was transferred to Turkey Cove, McDowell county, and used in the exploration of the marble deposits which were found there, and the work was continued there under the supervision of Mr. Spoon. Four holes were bored into these deposits, 296; 101; 253, and 94 feet in depth, respectively; the holes being located in such positions as to indicate a total thickness of more than a thousand feet of marble. The general results of this investigation showed that, while a considerable portion of the stone, on account of its fractured condition, would be unsuitable for architectural purposes, there are considerable masses of it which will be found satisfactory for such uses, and the larger part of the fractured stone might be used in the making of lime.

THE WORK OF THE STATE GEOLOGIST.

In addition to the work in connection with the examination of the building stone and the geology of the eastern counties the State Geologist has co-operated with the persons engaged in all the work described above, and in addition to that he has attended to the large correspondence of the Survey and the general office work; thus, as far as possible, giving his personal attention to all of the details connected with the work.

The correspondence of the Survey since its inauguration has required the answering of about 3,000 letters, many of which

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necessitated a considerable expenditure of time and energy, either in the examination of mineral specimens or the bringing together of information concerning mineral and timber resources.

The keeping of accounts in connection with the disbursements of the funds of the Survey has also added considerably to the work done by the State Geologist, and the editorial work necessary in preparing for publication the reports now approaching completion is adding still further to the demands on his time. In the future the amount of this editorial work connected with the preparation and publication of the reports of the Survey will be considerably increased; and this will require the turning over of much of the office work to a regular assistant employed for this purpose.

MISCELLANEOUS WORK.

In addition to the regular work of the Survey as outlined above a limited amount of work was done in several additional directions, the following being the most important:

TOPOGRAPHY.—During the months of October and November, 1891, Mr. Hersey Monroe was assigned by the United States Geological Survey to work in North Carolina, and during that time he revised the topographic atlas sheet covering the important iron ore regions of Ashe and Alleghany counties. During the entire field season of 1892 Mr. Monroe was again assigned to work in North Carolina and revised the Cranberry atlas sheet, which includes Watauga and parts of adjacent counties. Mr. C. E. Cook was assigned by the United States Geological Survey to work in revising the topography of the Murphy atlas sheet covering portions of Cherokee county.

PHOTOGRAPHY.—During the two years (1891 and 1892) several hundred photographs were taken by the Survey of the forests, mineral properties, and landscape scenery of the State. Many of these are to be used for illustrations in the reports, but the larger part of them were taken with a view to their exhibition as a part of the North Carolina exhibit at the Columbian Exposition, Chicago. Quite a number of these photographs are being copied, without expense to the State, and these copies will be widely distributed through many of the Northern and Western States, and will doubtless be the means of interesting a considerable number of people in the resources of this State.

Collections for the Columbian Exposition.—During 1892 while engaged in the general work of the season each member of the Survey staff collected for the North Carolina exhibit at the Columbian Exposition such specimens of building stone, ores, minerals and timbers as could be secured without too great a loss of time. And under the direction of the Board of World's Fair Managers, and at their expense, Mr. Nitze went to Chicago, and gave about one month's time in the spring of 1893 to the arrangement of the North Carolina mineral exhibit at the World's Fair.

CO-OPERATION FROM THE UNITED STATES GEOLOGICAL SURVEY.

During the past two years the United States Geological Survey has co-operated with the State Survey on a liberal scale, mainly along the line of the topographic work already mentioned. In addition to the work of Messrs. Monroe and Cook alluded to above another topographic party was at work during 1891 and 1892 in the piedmont counties. This topographic work must be done in advance of the geologic work, and hence the preparation of such a map as that which is being made will prove of great value to North Carolina. Already over 12,000 square miles have been surveyed and mapped—nearly one-fourth of the total area of the State. This work has cost to date more than $50,000, the entire amount being paid by the United States Geological Survey.

In addition to the topographic work Mr. Arthur Keith, of the United States Geological Survey, was assigned to geologic work in Cherokee county during the latter part of 1892. And valuable assistance was rendered the State Survey in the spring of 1892 by Professor C. R. Van Hise, Professor R. Pumpelly and Mr. Baily Willis, and in the summer of that year by Professor George H. Williams—all of the United States Geological Survey.

CHEMICAL ANALYSES AND ASSAY WORK.

Arrangements have been made for the analysis or assay of all samples collected by persons connected with the Survey in the prosecution of its regular work, and a considerable number of such analyses have been made already. But it will be apparent to all thoughtful persons that the Survey cannot undertake to make analyses of miscellaneous samples of minerals, ores and waters, collected by other parties, either gratuitously or for a consideration, and for the following reasons:

(1). The making of such analyses would necessitate the employment of one or more extra chemists for this purpose; and each analysis would cost the Survey nearly or quite as much as it would cost the sender to have it made elsewhere, while the sender alone would be benefited thereby; and the benefits to him would be of doubtful value for the reason that,—

(2). Miscellaneous specimens sent in by outside parties are not usually collected in such a way as to secure an average sample, and hence an analysis of it usually indicates very little as to the value of the mineral deposit. Often the samples sent in have been picked up on the surface soil and hence do not represent any known deposit whatever. And hence while the analyses of such samples would be a heavy expense to the Survey they would be of real service neither to the Survey nor to the person sending them.

(3). The analysis of samples collected by persons employed on the Survey requires the full time of the chemist.

SAMPLES SENT TO THE SURVEY FOR EXAMINATION.

While the State Geologist cannot undertake the making of costly chemical analyses of miscellaneous specimens of rocks, minerals and soils for the reasons stated above, he will always be ready to examine free of charge samples of ores or minerals for citizens of the State, and give an opinion as to the probable value of the sample, and where an elaborate chemical analysis or assay is found to be necessary he will be glad to advise with parties sending the samples as to how and where such analyses can be made, and the approximate cost of the same.

The following suggestions are made for the guidance of citizens of the State desiring to send such samples for examination:

1. Each sample should be accompanied by a statement placed inside the package, as to the exact location where found, name of

the sender, name of the owner of the land on which it was found; whether the sample was found as a loose fragment or broken from some large mass of similar mineral.

2. Each package should be addressed to the *State Geologist, Raleigh, N. C.*, and the name of the sender should be written plainly on the outside of the package.

3. Specimens may be sent by mail, express or freight. In either case the transportation charge should be fully prepaid.

4. The State Geologist cannot be held responsible for the loss of samples *en route* for his office or returning to the sender.

RELATIONS OF THE SURVEY TO PRIVATE INVESTMENT.

In order that the relation of persons connected with the Survey to private work or investments in mineral properties may be clearly understood, the following rules were adopted at the commencement of the work:

1. No person in the employ of the Survey will be permitted to acquire a personal interest in any mineral property in the State which has been or is to be examined and reported on by the Survey.

2. The discovery of valuable mineral deposits on the lands of any citizen of the State shall be made known to the owner of such lands before the information has been given to other parties or to the public.

EXPENSES OF THE GEOLOGICAL SURVEY.

The appropriation for the work of the Geological Survey is $10,000 per annum. Vouchers are collected for all moneys paid out on the Survey account, and monthly itemized certified statements of all such expenditures, with accompanying vouchers, are deposited with the State Auditor after having been examined and approved by the Geological Board. The following statement of the expenses for the two years ending November 30, 1892, showing the objects for which the amounts were paid, has been made up from these vouchers for 1891 and 1892:

Expenses of the Geological Survey for the Two Years Ending November 30, 1892.

Iron ore investigations	$ 3,686 42
Coal investigations	957 18
Forestry investigations	431 17
Mineral exploration	2,669 88
Building stone investigation	1,303 53
Chemical work and materials	1,481 08
Photographic work and materials	656 59
Topography	122 63
Clerical assistance	423 51
Instruments	176 99
Equipment and repairs*	2,368 67
Stationery and printing	112 05
Books	92 55
Salary of State Geologist (two years)	4,354 12
Expenses of Geological Board meetings	67 15
Diamond drill explorations for coal and marble	1,020 45
Miscellaneous	76 03
Total	$20,000 00

THE FUTURE WORK OF THE SURVEY.

The work of the Survey during 1893 and 1894 will be pushed more rapidly and will include a wider range of subjects than that of the past two years, as shown by the following list of subjects the investigation of which is now being begun. The list also includes some of the subjects the investigation of which was begun during the past two years but which has not been completed. The list is as follows:

1. The iron ores.
2. The building and ornamental stones.
3. The clays and kaolins.
4. The corundum deposits of the south-western counties.
5. The monazite deposits of Clay, Rutherford, McDowell, and Burke counties.
6. The gold deposits of the piedmont and middle counties.
7. The timber resources of the State.
8. The protection of our forests against fires and other destructive agencies.

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*This expenditure for equipment is much larger for these two years than it will be in the future, on account of the necessary outlay for tents, wagons, horses, office furniture, etc., in the beginning of the Survey work.

9. The water powers and their development.
10. The mineral waters and other drinking water supplies.
11. The road materials and construction.
12. The lime and phosphate deposits in south-eastern counties.
13. The geologic formations and the resulting soil products.

SOME BENEFITS RESULTING FROM THIS WORK.

These subjects mentioned above reach every section of the State and every class of people; so that the benefits of the Survey, both direct and indirect, are becoming more widely disseminated. Among these benefits it may be said that the Survey has already been largely instrumental in bringing into the State not less than a million dollars of investments in mineral, timber and water-power resources; and the prospects are that these investments will be considerably increased during the next few years.

This, however, is but a partial estimate of the benefits to be derived by the people of the State from work of this kind by the Geological Survey. It serves to educate them up to an appreciation of the natural resources that surround them, and enables them to join intelligently in the development of these resources of all kinds, and thus to build up diversified industries; and thereby increases the material wealth of the community. Furthermore by advising against mining operations in cases where they would undoubtedly result in failure, the Geological Survey prevents the useless expenditure of considerable amounts of money by citizens of the State.

IRON ORES OF NORTH CAROLINA,

BY

H. B. C. NITZE.

CONTENTS.

PAGE.

- Introductory statement 29
- The structure of the ore deposits 30
- Some important iron ore deposits 31
  - Ore Hill, Chatham county 31
- Central magnetite ore belts 35
  - Magnetite ores of Stokes county 37
    - William Nelson "hard ore" bank 38
    - Lee Nelson ore bank 38
    - Rodgers mine 39
    - Pepper mine 40
    - Isaac Fagg ore bank 40
  - Magnetite ores of Surry and Yadkin 41
  - Iron ores of Gaston, Lincoln and Catawba 41
    - Big ore bank 43
    - Limestone belt 45
    - Ormond mine 45
    - Little mountain mine 47
    - Yellow ridge belt of ores 48
- Iron ores of the mountain counties 48
  - Magnetite ore belts in Ashe county 48
    - Ballou or River belt 48
    - Red-hill or Poison-branch belt 49
    - Titaniferous ore belt 50
  - Iron ores in Mitchell county 51
    - Cranberry magnetite belt 52
  - Iron ores in Madison county 54
  - Brown hematite deposits, Cherokee county 55

IRON ORE DEPOSITS IN NORTH CAROLINA.

By H. B. C. Nitze.

INTRODUCTORY STATEMENT.

A fuller statement of the results of the work done on the iron ores of the State will be published in Bulletin No. 1, entitled "Iron Ores of North Carolina." As stated in the preface of that bulletin, the subject-matter was derived from personal investigation in the field during the seasons of 1891 and 1892, beginning in June, 1891. During this time all of the most important iron ore deposits in the State were visited and as detailed an examination given them as the scope of the work and the purposes of a preliminary report would justify. Particular attention was paid to the region west of the Blue Ridge mountains, because of the advantage offered by the topographic maps of the United States Geological Survey, which have been completed for this portion of the State.

The total area examined in different portions of the State amounts to some 6,000 square miles, distributed over twenty-three counties.

This report deals with descriptions of the localities, the extent and character of the ore deposits, as far as possible, and the quality of the ores as determined by analyses. A map of the State, showing the position of the various iron ore deposits, has been prepared and will accompany Bulletin No. 1. A table of 453 analyses, showing the character and locality of the samples, and the names of the chemists by whom analyzed, will also be appended. Some of these analyses are included in the present statement and are given here the same numbers as they have in Bulletin No. 1.

During the field season of 1893 work on the iron ore deposits and on the general geology of the iron-bearing rocks will be continued along the line of the great Smoky mountains, for the most part in conjunction with Mr. Arthur Keith of the United States Geological Survey.

Some brief, general statements showing the result of the work on the iron ore deposits may be here given, as follows:

The ores of iron are found widely distributed in the State. The magnetites and red hematites are found almost exclusively in the crystalline rocks, which are confined to the midland and western counties. The true bedded deposits of brown hematite occur in the lower Paleozoic rocks in the extreme western part of the State, in Madison county, west of Hot Springs, and in the extreme southwestern corner of the State, in Cherokee county. Brown hematite is, however, variously distributed throughout the crystalline rocks, sometimes in important masses; as at Ore Hill in Chatham county, the Ormond mine in Gaston county, etc.

The carbonate ores (blackband, ball ore, etc.) are confined to the coal measures of the Triassic. Siderite also occurs as a gangue mineral in some of the gold ores, as at Silver Valley, and Conrad Hill in Davidson county; but not in sufficient quantity to make it of economic value as an iron ore.

The bog ores are found in isolated patches over the more recent formations of the coastal plain region, in the eastern part of the State.

The chromic iron ores occur in the chrysolite rocks in the western part of the State.

THE STRUCTURE OF THE ORE DEPOSITS.

The magnetites and specular hematites of the crystalline rocks are lenticular deposits, pinching and swelling out in all dimensions. These lenticular or cylindrical bodies vary widely in size, being at times so small as to practically preclude working; again they attain enormous development in length, thickness and depth, as at the Cranberry mine in Mitchell county. The enclosing crystalline rocks are for the most part schists and gneisses, micaceous and horndblendic; but granitic, dioritic, diabasitic and even more basic eruptives also occur in this position.

The brown hematites usually occur in irregular pocketed beds. In Madison and Cherokee counties the beds are more regular and quite persistent. They occur surrounded by a stiff pipe clay in the calcareous schist, overlying the limestone and underlying the quartzite. These lower Paleozoic rocks are considerably metamorphosed, and at times become difficult to distinguish from the more ancient crytalline schists. There are two localities in the State where brown hematite occurs apparently in veins, as far as our present knowledge goes: At Ore Hill, in Chatham county, it occurs in almost vertical dikes, which often intersect each other. On Little mountain, in Gaston county, the ore occurs in a heavy, vertical quartz vein.

The blackband and ball ores of the coal measures occur in regular stratified layers or seams, conformable to the carbonaceous shales and slates.

Red hematite ore occurs similarly inter-stratified in the Triassic sandstone in Chatham and Moore counties.

The bog ores occur as local deposits, usually in swampy or marshy places, or around the mouths of springs from which they have been deposited. They cover comparatively small areas, and are altogether irregular in extent.

SOME IMPORTANT IRON ORE DEPOSITS.

Among the more important deposits in the State are:

1. The brown hematites of Ore Hill, Chatham county.
2. The magnetite ores of Stokes, Surry and Yadkin counties.
3. The magnetite and brown hematite ores of Catawba, Lincoln and Gaston counties.
4. The magnetite ores of Ashe, Mitchell and Madison counties.
5. The brown hematite ores of western Madison and of Cherokee counties.

Some of these are still inaccessible, but with their proper development and proof of the existence of large deposits of good ore, railroad connections will not be long in reaching them.

ORE HILL, CHATHAM COUNTY.

Ore Hill is situated forty miles south-east of Greensboro on the Cape Fear & Yadkin Valley Railway. Its elevation is about 300 feet above the level of Ephraim's creek, and it covers about 340 acres. It is the property of the North Carolina Steel and Iron Company.

The country rock is a quartzose talc-slate, knotted and toughened with much tremolite. The ore is brown hematite, with the exception of one vein near the top and back of the hill, which is red hematite, partly specular. A satisfactory explanation of the geologic structure of these ore deposits cannot at present be given. It will require a special study, aided by more extensive development of the mines. It cannot be said now whether these deposits of brown hematite are dikes, regular contact veins or lodes, or gossans. The fact that analyses of the ore show low percentages of sulphur, even where the water level has been reached, rather excludes the last idea. All present indications point to the existence of the ore bodies in regular veins, between regular walls, dipping at very steep inclinations, and having variable strikes.

There are many openings on the hill, some of which have caved in and partially filled up. The more important of these are indicated on the accompanying map (Plate II). They are here briefly described as follows:

Opening No. 1, 1,400 feet south of the railroad, and 207 feet above the same in elevation. It is a large open cut in the face of which a body of brown hematite from 10 to 20 feet thick is exposed. It has been explored by drifts 200 feet long in a due south direction; on the western side of the cut a smaller ore-body has been explored by a drift 40 feet long in ore.

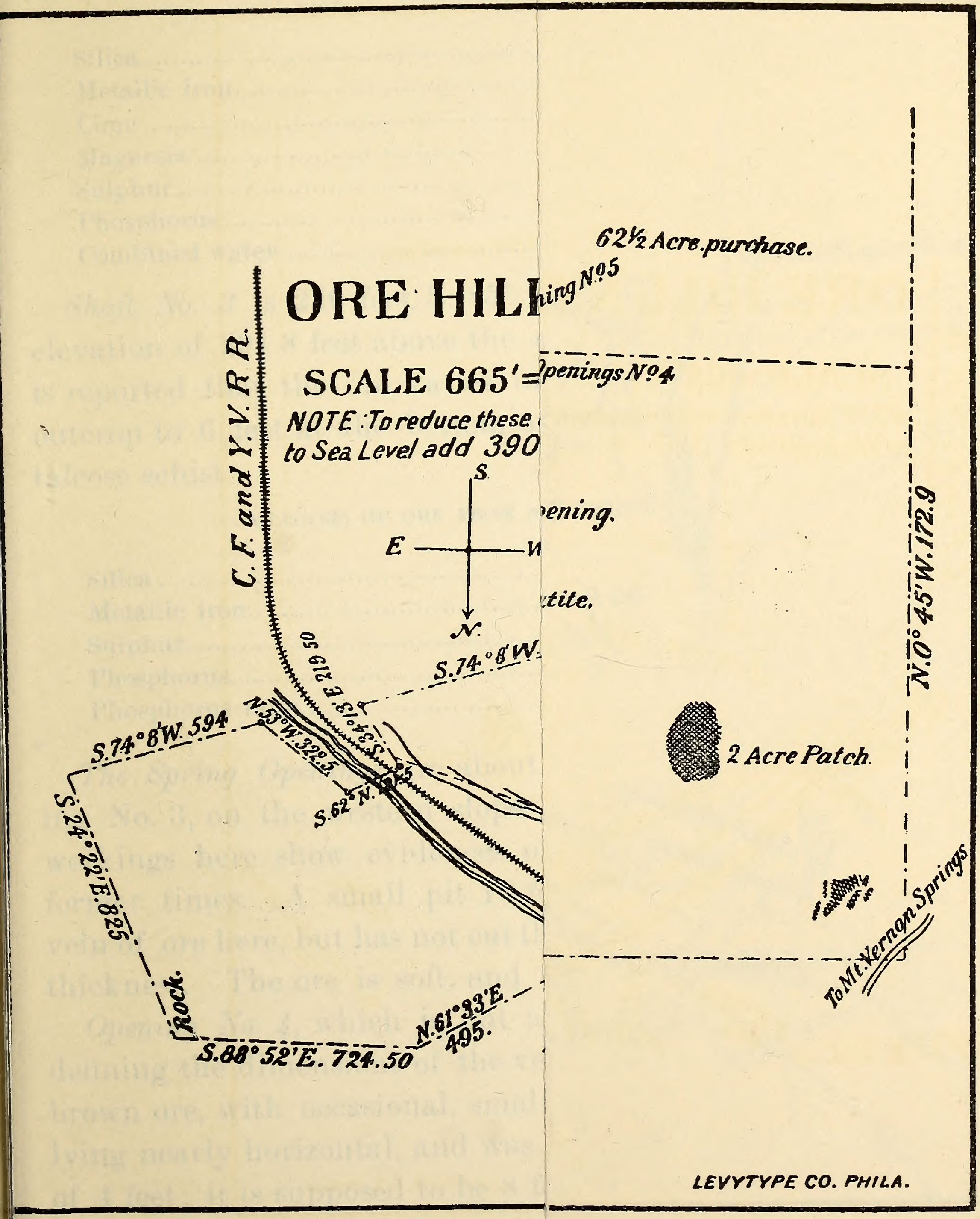
ANALYSIS OF ORE; OPENING NO. 1, ORE HILL, CHATHAM COUNTY.

	(119)
Silica	4.73
Metallic iron	47.87
Sulphur	0.34
Phosphorus	0.069
Phosphorus ratio	0.144

Opening No. 2, 400 feet N. 60° W. from No. 1, at an elevation of 284.6 feet above the railroad. This is a shaft 80 feet deep. The thickness of the vein is not known, but it is supposed to be over 5 feet. Near here a vein of soft ore has been prospected by a short drift, showing 6 feet of ore.

The Whim Shaft is 400 feet S. 30° W. from opening No. 2, at an elevation of 307 feet above the railroad. It is 90 feet deep; the strike of the vein is S. 15° E.; the dip is vertical. The thickness

N. C. GEOLOGICAL SURVEY. FIRST BIENNIAL REPORT PLATE II.



MAP OF ORE HILL, SHOWRON COMPANY.

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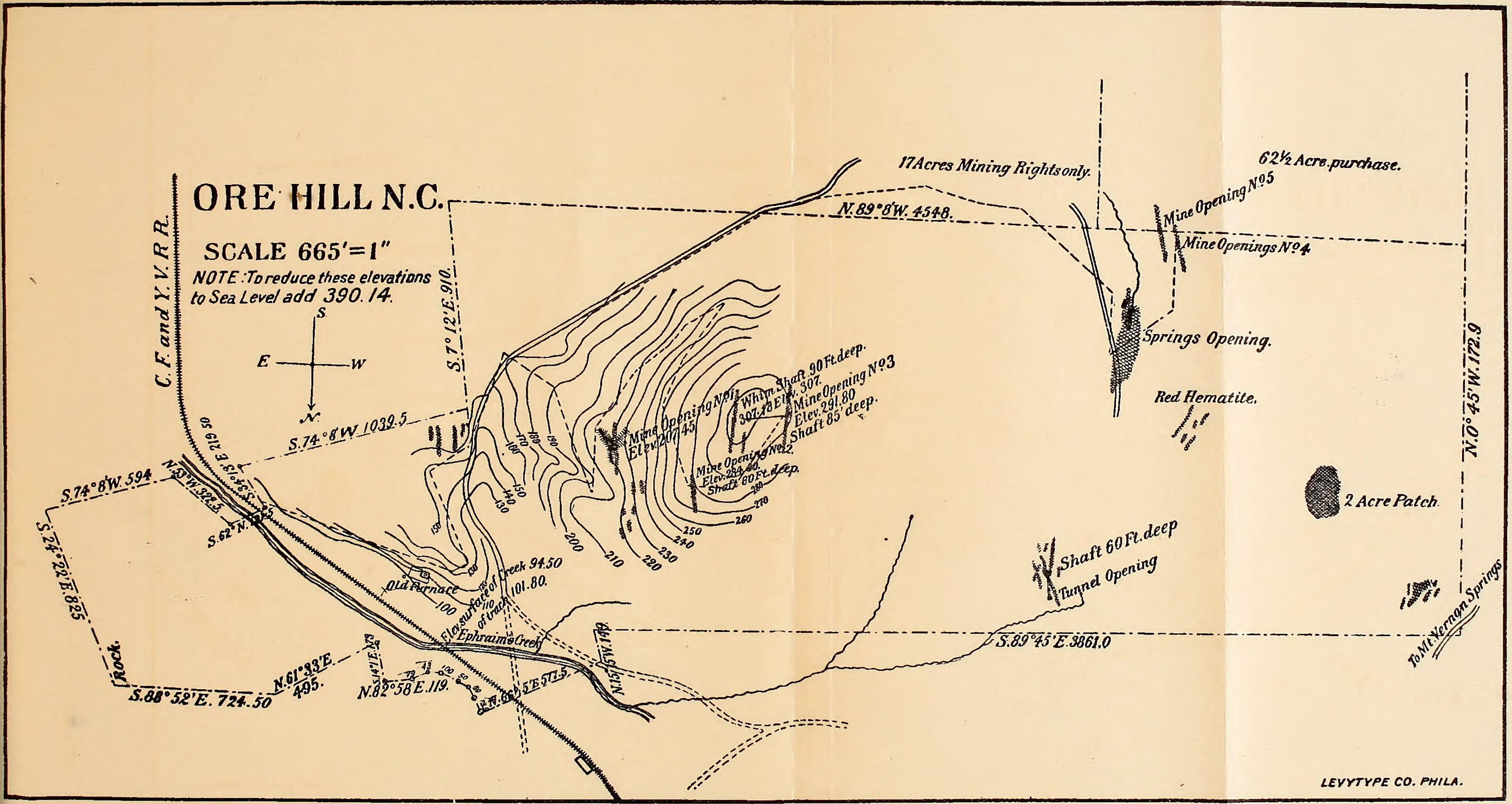


MAP OF ORE HILL, SHOWING THE RELATIONS OF THE IRON ORE DEPOSITS, AND THE PROPERTY BOUNDARIES OF THE NORTH CAROLINA STEEL AND IRON COMPANY.

of the ore varies from 15 inches on the outcrop to 2½ feet at the bottom of the shaft. Two analyses from this locality show:

ANALYSES OF ORE FROM 90-FOOT SHAFT, ORE HILL CHATHAM COUNTY.

	(120)	(121)
Silica	1.42	3.79
Metallic iron	57.26	58.67
Lime	1.19	
Magnesia	0.11	
Sulphur		0.33
Phosphorus		trace
Combined water	15.26	

Shaft No. 3 is 240 feet S. 85° W. from the whim shaft, at an elevation of 291.8 feet above the railroad. It is 85 feet deep. It is reported that the ore varies in thickness from 1½ feet on the outcrop to 6 feet at the bottom of the shaft. The wall rock is a talcose schist.

ANALYSIS OF ORE FROM SHAFT NO. 3, ORE HILL.

	(122)
Silica	2.35
Metallic iron	47.23
Sulphur	0.28
Phosphorus	0.139
Phosphorus ratio	0.294

The Spring Openings are about 1,500 feet S. 75° W. from opening No. 3, on the western slope of the hill. Some old caved-in workings here show evidences of quite extensive operations in former times. A small pit 10 feet deep has partially exposed a vein of ore here, but has not cut through, nor in any way defined its thickness. The ore is soft, and apparently of very good quality.

Opening No. 4, which is but a small pit, without in any way defining the dimensions of the vein, shows up a compact, purplish-brown ore, with occasional, small, cherty seams. It appears to be lying nearly horizontal, and was penetrated by the pit to a depth of 4 feet; it is supposed to be 8 feet thick.

ANALYSIS OF ORE FROM OPENING NO. 4, ORE HILL.

	(123)
Silica	17.32
Metallic iron	42.88
Sulphur	0.23
Phosphorus	0.106
Phosphorus ratio	0.247

Opening No. 5 is a small pit near No. 4, 12 feet deep, cutting a vein 8 feet thick as far as exposed; character of ore similar to No. 4.

ANALYSIS OF ORE FROM OPENING NO. 5, ORE HILL.

	(124)
Silica	5.13
Metallic iron	39.17
Sulphur	0.18
Phosphorus	0.064
Phosphorus ratio	0.163

The Tunnel Opening is about 1,800 feet N. 18° E. from the Spring openings, very near the northern boundary line of the Ore Hill property. A tunnel has been driven here in a south-westerly direction, striking the ore-vein on the hanging wall side, but as it has not cut through it the thickness of the vein cannot be determined.

ANALYSIS OF ORE FROM THE TUNNEL OPENING, ORE HILL.

	(125)
Silica	3.71
Metallic iron	49.79
Sulphur	0.17
Phosphorus	0.038
Phosphorus ratio	**0.076**

Between the Tunnel openings and openings Nos. 4 and 5 are several small openings, on the red hematite vein, which is practically nothing more than a very siliceous ferruginous slate, with occasional small streaks of fairly good specular ore, some analyses of which are appended below; but it does not exist in a sufficient quantity, and is therefore valueless from an economic stand-point.

ANALYSES OF RED HEMATITE FROM ORE HILL, CHATHAM COUNTY.

	(117)	(118)
Silica	24.44	......
Iron	49.00	45.70
Sulphur	0.05	......
Phosphorus	0.037	0.252
Phosphorus ratio	**0.07**	0.551

Below are given a number of additional analyses, showing the composition of the brown hematite ores from Ore Hill, collected from various sources :

OTHER ANALYSES OF BROWN HEMATITE FROM ORE HILL, CHATHAM COUNTY.

	(126)	(127)	(128)	(129)	(130)	(131)	(132)	(133)	(134)	(135)	(136)	(137)
Silica	1.30	....	6.58	1.86	......	......	......	......	......	......	......	......
Metallic iron	58.76	42.29	53.20	59.62	56.78	60.90	56.17	40.32	57.69	50.24	56.66	46.57
Alumina.	2.44	......	......	2.24	......	......	......	......	......	......	......	......
Sulphur	0.270	....	0.170	......	0.158	......	......	......	......	......	......	......
Phosphorus	0.400	0.235	0.041	0.224	0.488	0.219	0.430	0.182	0.833	0.822	0.641	0.213
Titanic acid	1.070	......	......	......	......	......	......	......	......	......	......	......
Combined water	9.54	......	......	10.00	......	......	......	......	......	......	......	......
Phosphorus ratio.	0.681	0.556	**0.077**	0.375	0.859	0.359	0.765	0.451	1.443	1.636	1.131	0.457

Considered from a mineralogic stand-point these ores are hydrated oxides of iron, varying in their percentage contents of combined water, as shown by analyses Nos. 120, 126 and 129, from 9.54 to 15.26 per cent., the former approaching very nearly to the true goethite and the latter to limonite. Practically they are known without special distinction as brown hematites.

Considered from an economical stand-point the foregoing analyses show the ores to range from 39.17 to 60.90 per cent, of metallic iron, and from 0.038 to 0.833 per cent. of phosphorus. The silica is uniformly very low, with the exception of one, namely, analysis No. 123, from opening No. 4, where small grains of quartz occur disseminated in the ore.

It is believed that an average of from 45 to 50 per cent. of metallic iron can be obtained in actual mining.

As far as the phosphorus is concerned the variations are so great that no absolute statements can be made as to the average run of the ores in practice; they will probably approach nearer to from $\frac{2}{10}$ to $\frac{4}{10}$ of one per cent. on an average. Only two analyses out of 19 (Nos. 125 and 128) show a phosphorus ratio under the Bessemer limit; and, while certain isolated masses of Bessemer ore may be found, the deposit, as a whole, cannot be depended on to furnish Bessemer ores.

Considered from all aspects, the ores are of excellent quality, and possess the advantage of being clean, not necessitating washing.

CENTRAL MAGNETITE ORE BELTS.

In the central part of the crystalline area of the State a wide and, generally speaking, persistent belt of magnetic iron ore extends across the State in a south-westerly direction from Virginia to South Carolina.

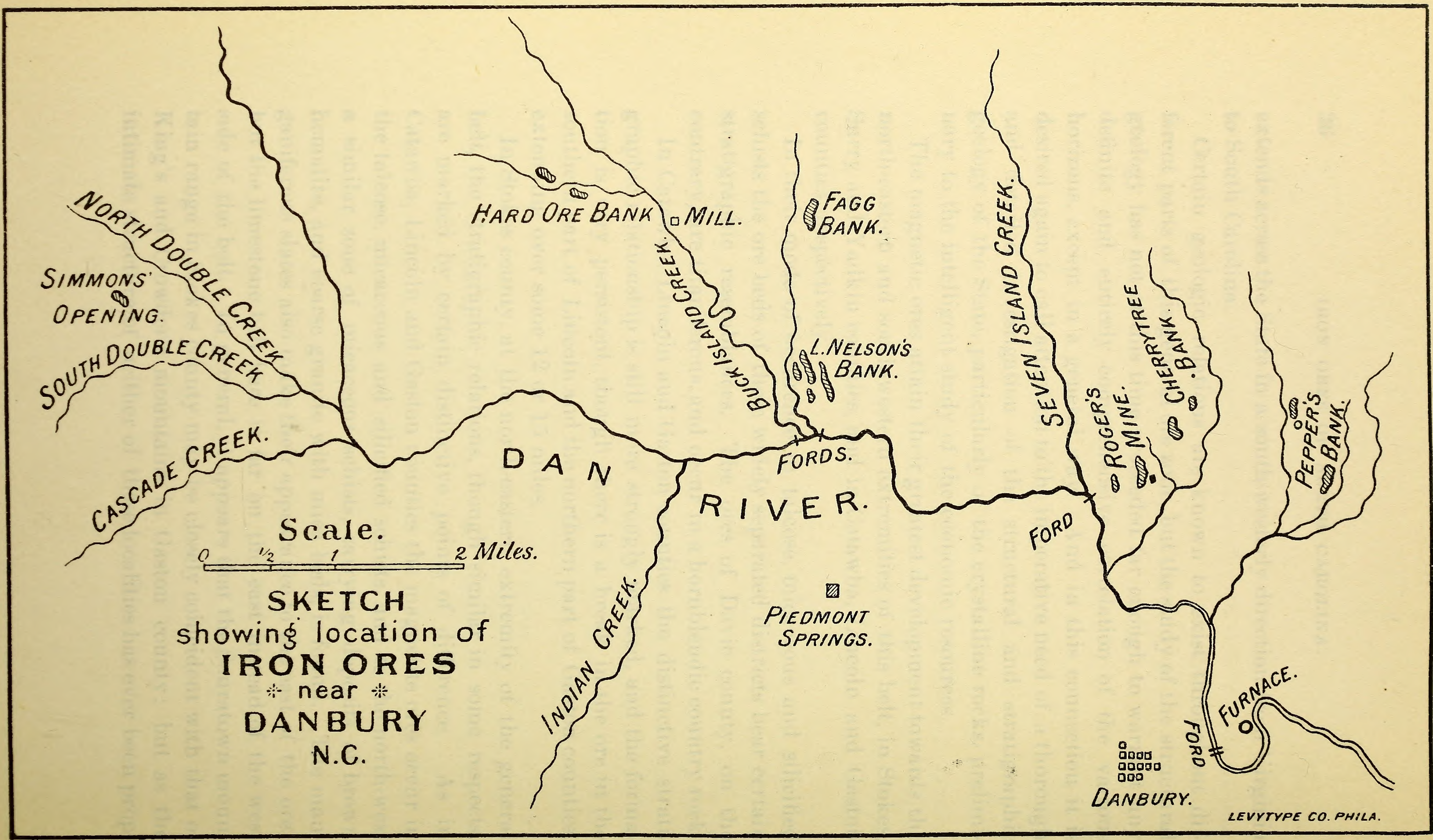
Certain geologic relations are known to exist throughout different parts of this general ore zone, but the study of the structural geology has not at this time proceeded far enough to warrant any definite and entirely comprehensive correlation of the various horizons, except in a general way. And in this connection it is desired again to call attention to the imperative need of a thorough and detailed investigation of the structural and stratigraphic geology of the State, particularly of the crystalline rocks, preliminary to the intelligent study of the economic resources.

The magnetic ores attain their greatest development towards the north-eastern and south-western extremities of this belt, in Stokes, Surry and Yadkin counties, and in Catawba, Lincoln and Gaston counties, respectively.

In their mode of occurence in talcose, micaceous and silicified schists the ore beds of these widely separated districts bear certain stratigraphic resemblances. The ores of Davie county, on the contrary, are titaniferous, and occur in a hornblendic country rock.

In Catawba, Lincoln and Gaston counties the distinctive stratigraphic relationship is still more strongly marked, and the formation is very persistent, though there is a break in the ore in the southern part of Lincoln and the northern part of Gaston counties, extending over some 12 or 15 miles.

In Stokes county, at the north-eastern extremity of the general belt, the stratigraphic relations, though similar in some respects, are marked by certain distinctive points of difference. As in Catawba, Lincoln and Gaston counties the magnetite ores occur in the talcose, micaceous and silicified schists, and to the north-west a similar zone of micaceous schists, carrying deposits of brown hematite, and coarse granite with mica beds, is found. The manganiferous slates also make their appearance to the east of the ore; but the limestone belt here is far on the east instead of the west side of the belt. In general, it appears that the Sauratown mountain range in Stokes county may be closely coincident with that of King's and Crowder's mountains in Gaston county; but as the intimate structure of neither of these localities has ever been prop-



IRON ORE DEPOSITS, STOKES COUNTY.

erly studied we are practically in the dark concerning the relations of the ore deposits.

As far back as 1856, Dr. Emmons says:* "At rather distant points the ore of this belt appears in a range so direct that there is no doubt of its passing entirely across the State; it lies parallel with the limestones and slates; there is some doubt respecting the age of the limestone at Germantown ; that is, it seems to be different from the King's Mountain limestone." After further consideration he concludes that "there will be no objection to combining the Stokes county and King's Mountain belts."

THE MAGNETITE DEPOSITS OF STOKES COUNTY.

The principal deposits of magnetite ore in Stokes county are situated on the north side of the Dan river. Their locations are indicated on the accompanying sketch map (Plate III).

The ores occur in a series of parallel belts, occupying a width of about 4½ miles, which have been traced in a south-westerly direction for over twenty miles, crossing the Yadkin river into Yadkin county. In a north-easterly direction they continue into Henry county, Va.

Lying to the east of the magnetite ores, a belt of limestone crosses Stokes county in a north-easterly direction from Germantown; but it has been found too siliceous to be of a practical value in iron smelting.

The ores of this district may be divided into three classes:

1. Hard ore. 2. Soapstone ore. 3. Sand ore.

This is the vernacular nomenclature, and is meant to be descriptive of the structured characteristics of the ores.

1. The "hard ore" is a hard, compact, massive, crypto-crystalline magnetite.

2. The "soapstone ore" is a soft, greasy mass, composed of crystalline grains of magnetite disseminated through a matrix of talcose and micaceous schists, resembling Lieber's "catawbarite" of South Carolina.

3. The "sand ore" is composed of magnetite grains disseminated through a sandy matrix; it is also soft and friable.

---

*Geological Report of the Midland Counties, 1856, p. 119—quotation slightly altered.

ANALYSES—CONTINUED.	(349)	(350)	(351)	(352)
Alumina	......	0.70	2.27	0.17
Magnesia	0.20	0.16	0.17	0.23
Lime	0.13	0.29	0.31	0.19
Phosphoric acid	none.	none.	none.	none.
Actinolite	7.20	13.76	15.66	31.75
Water	......	......	1.88	......
Metallic iron.	65.34	61.74	57.13	49.03

These analyses show very wide variations, due undoubtedly to the varying nature of the ore bed itself. But in what proportion these different grades of ore are distributed in the bed can only be determined by careful examination of the deposit in place, which, until the mine is cleaned out and again developed, is naturally impossible. Dr. Genth has described the ore as being absolutely free from phosphorus, but he probably meant that it was *very low* in phosphorus, so low that it was not considered worth while to determine it. However, the importance of determining even the very smallest per cent. of this element must not be overlooked, for to the iron manufacturer it is always an important factor in estimating the true value of the ore.

Analyses 347, 348 and 348a show its presence, though in very minute quantity, and safely below the Bessemer limit.

THE PEPPER MINE is another of these old, abandoned ore banks. It lies 2½ miles north-east of Danbury and about 1½ miles east of the Rogers mine. The ore is a granular magnetite, disseminated in mica schist, and the old workings were apparently of considerable extent. A tunnel is said to have cut the ore from 6 to 8 feet in thickness.

ANALYSIS OF ORE FROM THE PEPPER BANK, STOKES COUNTY.

	(354)
Metallic iron	44.08
Phosphorus	0.033
Phosphorus ratio	**0.075**

THE ISAAC FAGG ORE BANK is situated 4 miles north-west of Danbury, and 1 mile north-east of the Lee Nelson bank. The ore deposit consists of a series of sandy ore seams of variable and irregular thickness—reaching 4 feet at one point. It belongs to the class called "sand-ore." The cap rock is a decomposed gneiss, dipping about 30 degrees slightly west of north.

ANALYSES OF ORE FROM THE ISAAC FAGG BANK, STOKES COUNTY.

	(355)	(356)
Silica	25.47	18.35
Metallic iron	42.48	48.62
Sulphur	0.049	0.021
Phosphorus	0.079	0.117
Titanic acid	......	0.170
Phosphorus ratio	0.186	0.240

All prospects point to the existence of large and valuable deposits of magnetic ore in the Danbury region. They lie well for mining, and the numerous creeks and hollows make them easily accessible to the river bank. The nearest railroad point to Danbury is Walnut Cove, 11½ miles south-east, at the junction of the Norfolk & Western and the Cape Fear & Yadkin Valley roads. A branch road has been surveyed along the ridge road from Walnut Cove to the head of Poor-house branch; down the valley of that branch to Flat Shoals creek; with the valley of said creek to the Dan river, and up the river to Danbury; and when this is built there is no reason why these ores should not find a market.

MAGNETITE ORES IN SURRY AND YADKIN COUNTIES.

The ores of Surry and Yadkin counties consist of magnetite grains disseminated in mica schist and gneiss, resembling in that respect some of the Stokes county ores; and their economic value, as far as quantity is concerned, will thus in a great measure be dependent upon the cost of separating these magnetic grains from their gangue by means of magnetic concentration. The rock is usually decomposed to great depths, and is therefore well adapted to easy and cheap crushing, preliminary to concentration. Some of these deposits appear to become pyritous below the water level.

IRON ORES IN GASTON, LINCOLN AND CATAWBA COUNTIES.

The magnetites of Catawba, Lincoln and Gaston counties comprise a belt about 20 miles in length and several miles in width. Their general distribution is indicated on the accompanying outline map (Plate IV). The ores occur in the talcose, micaceous and silicified schists of a series of slaty ridges and knolls in Lincoln county, and along the eastern foot-hills of Anderson's mountain in Catawba county, having a general trend of N. 20° E. The beds are nearly vertical and dip sometimes to the east and sometimes to the west, but the westerly dips are by far the most frequent. For a considerable part of the belt in Lincoln county there are two parallel beds, the more westerly being the more productive, and the combined thickness being from 4 (rarely so low as 2) to 12 feet; the interval of 12 to 20 feet between them is occupied by talcose and chloritic schists, with a little ore in layers. The beds generally occur in lenticular masses or flat disks, which thicken at the middle and thin out towards the edges, having the same general dip as the bed; but they do not succeed one another in the same plane; their edges overlapping so as to throw the upper edge of the lower disk behind the lower edge of the upper. The following is an ideal section, illustrating this:

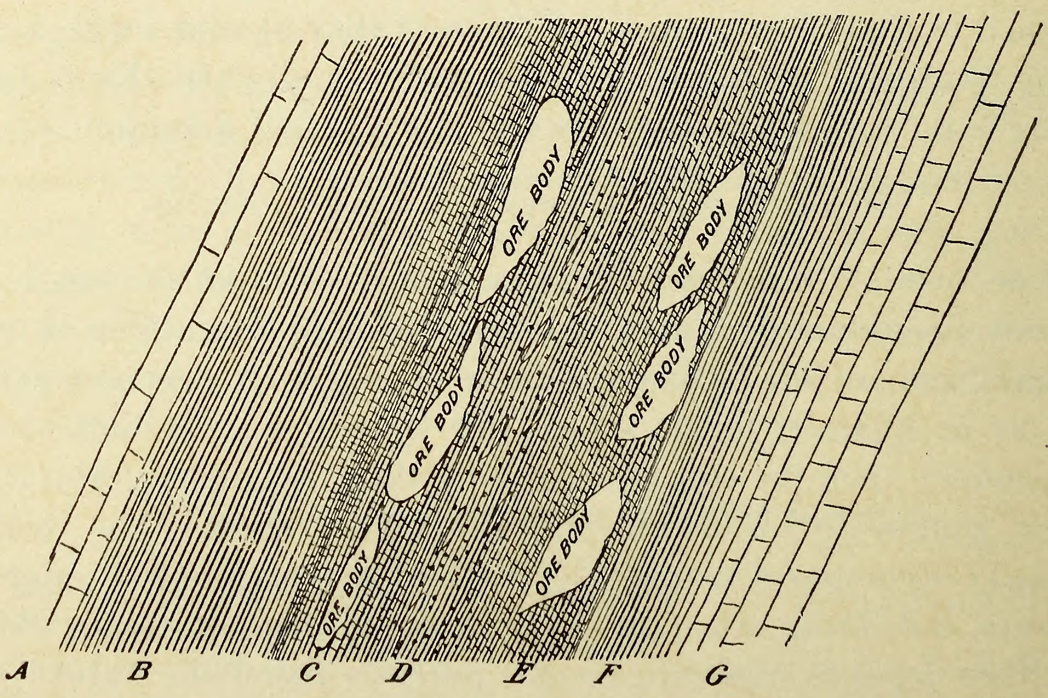
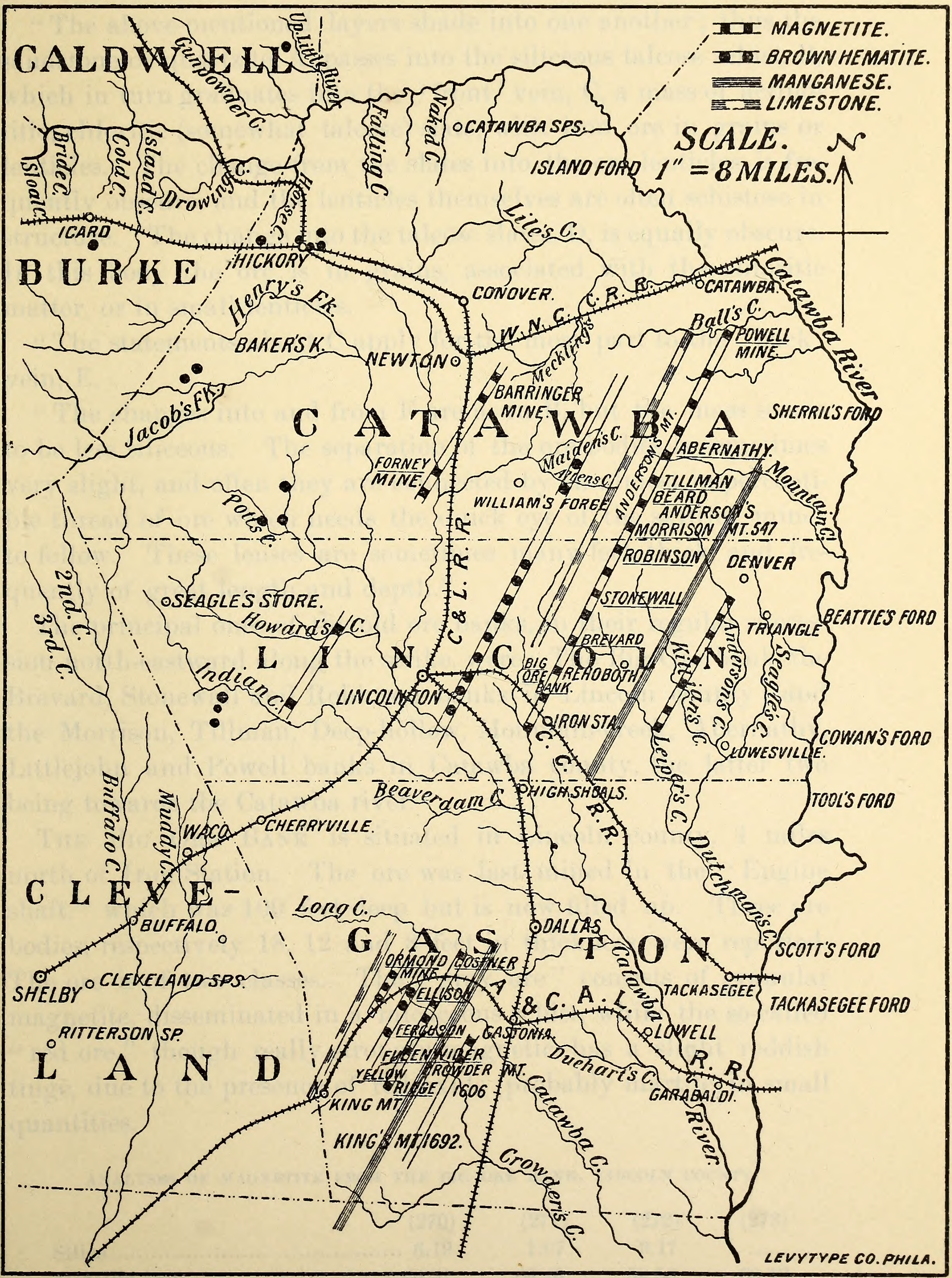


Fig. 1.—Ideal section, showing lenticular structure and position of magnetite ore beds, Lincoln county.

"A, sandstone or quartzite. B, talcose schist (slate). C, 'Front' ore bed of actinolitic, chloritic and somewhat talcose schists, containing ore bodies. D, talcose and chloritic schists, containing small quantities of ore, mostly in grains. E, 'Back' ore bed, for most part similar to C. F, talcose schist. G, gneiss.



IRON ORE DEPOSITS OF GASTON, LINCOLN AND CATAWBA COUNTIES.

"The above-mentioned layers shade into one another; thus the sandstone or quartzite, A, passes into the siliceous talcose schist, B, which in turn graduates into the 'front' vein, C, a mass of actinolitic, chloritic (somewhat talcose) slate, with iron ore in grains or lenticles. The change from the slates into the ore lenticles is frequently obscure, and the lenticles themselves are often schistose in structure. The change into the talcose slates, D, is equally obscure. In this body the ore is in grains, associated with the chloritic matter, or in small lenticles.

"The statements about C apply for the most part to the 'back' vein, E.

"The changes into and from F are as in B, but the mass seems to be less siliceous. The separation of the ore bodies is sometimes very slight, and often they are connected by an almost imperceptible thread of ore which needs the quick eye of the skillful miner to follow. These lenses are sometimes many feet thick, and frequently of great length and depth."

The principal ones of the old ore banks, in their regular succession north-eastward along the strike, were: The Big Ore bank, the Brevard, Stonewall and Robinson banks in Lincoln county; and the Morrison, Tillman, Deep-hollow, Mountain-creek, Abernathy, Littlejohn and Powell banks in Catawba county, the latter two being towards the Catawba river.

THE BIG ORE BANK is situated in Lincoln county, 4 miles north of Iron Station. The ore was last mined in the "Engine shaft," which was 100 feet deep but is now filled up. Three ore bodies, respectively 18, 12 and 8 feet in thickness, were reported. The ore is of two classes. The "gray ore" consists of granular magnetite, disseminated in a micaceous schist, while the so-called "red ore," though really strongly magnetic, has a slight reddish tinge, due to the presence of red oxide (probably martite) in small quantities.

ANALYSES OF MAGNETITE FROM THE BIG ORE BANK, LINCOLN COUNTY.

	(270)	(271)	(272)	(273)
Silica	6.19	1.07	9.17	......
Metallic iron	66.92	68.40	58.56	68.12
Alumina	......	......	2.46	......

ANALYSES—CONTINUED.	(270)	(271)	(272)	(273)
Lime	......	......	0.27	......
Magnesia	......	......	4.33	......
Sulphur	0.068	0.069	0.086	0.120
Phosphorus	0.082	0.072	0.013	0.006
Titanic acid	......	......	......	none.
Phosphorus ratio	0.124	0.105	**0.022**	**0.008**

No. 270. Gray ore, sampled from old stock pile at Rehoboth furnace.
No. 271. Red ore, sampled from old dump at mine.
No. 272. From shaft near water level.
No. 273. Red ore.

Not much can be said of the remaining portion of the Lincoln-Catawba part of this belt, for the mines have been deserted and are now inaccessible. This region was at one time the scene of active mining and smelting operations. Its abandonment was due, not to the lack of ore, but to the inaccessibility of the product to a market, and probably in a great measure to the lack of capital and energetic management. However that may be, the field is certainly worthy of a careful, practical investigation, which will require both time and money. The old shafts must be cleaned out, others must be sunk, unopened area must be explored and tested; in short, the ore bodies must be examined in place before an intelligent report of the probable extent and quantity can be made.

The erroneous supposition would be quite liable to occur to many that because these ores have been worked and smelted for so long a period as one hundred years they should be exhausted. This is fallacious; the old forges and furnaces, of small capacity, and working as spasmodically as they did, have not drawn on the ore supply sufficiently to make any material difference. For the most part, indeed, they obtained their ore from the very surface, or mined it in shallow pits along the outcrop, a method appropriately named "ground-hogging." In no instance have the shaft workings—and there are but few of them—extended below the water level. If the ore was ever there it is still there, without any appreciable difference in quantity.

Attention may be called to the possibility of the brown hematite zone running parallel to this belt on the west, affording sufficient quantities of soft ore to allow of a beneficial mixture.

LIMESTONE BELT.—Running parallel with these series of ore deposits, and directly west of the magnetic ore belt, is a narrow belt of dolomitic limestone which will serve as an excellent fluxing material. It has been opened at a number of points, among which may be mentioned the Shuford and Powell quarries in Catawba and the Keener quarry in Lincoln county.

The quality of this limestone is shown by the following analyses:

ANALYSES OF LIMESTONE FROM CATAWBA AND LINCOLN COUNTIES.

	(400)	(401)	(408)
Silica	1.28	2.60	0.45
Oxides of iron and aluminum	3.17	1.54	4.46
Lime	33.18	34.27	35.90
Magnesia	19.07	20.09	17.63

No. 400. From the Shuford quarry, Catawba county.
No. 401. From the Powell quarry, Catawba county.
No. 408. From the Keener quarry, Lincoln county.

This entire range of parallel ore deposits in Lincoln and Catawba counties may be made accessible by a railroad connection, some 24 miles in length, between the Western North Carolina and Carolina Central railroads, following almost the exact trend of the principal ore belt.

In Gaston county the ore-bearing formation consists of four parallel belts on the east side of the limestone: 1. That on which the Ormond mine is situated. 2. Little mountain. 3. Yellow Ridge. 4. Crowder's and King's mountains.

THE ORMOND MINE is situated 1 mile due west from Bessemer City, with which it is connected by a short branch railroad. This is probably the most interesting mine in Gaston county, because it has been most extensively worked, and is in fact the only iron ore mine, besides that at Cranberry in Mitchell county, that has been in operation during the past years. The country rock is silicified, talcose schist, decomposed to considerable depths. The strike is N. 25° to 30° E.; the dip is to the north-west from 75 degrees to the vertical.

The character of the ore is varied; practically speaking there are four classes: 1. A hard, block ore, solid and jointed in structure, containing generally less than 5 per cent. of combined water, and hence classified as *turgite*. 2. A loose, pulverulent, bluish-black ore, locally called *powder ore*, from its fineness and color. 3. A porous, brown hematite or *limonite*. 4. A very hard, homogeneous ore, almost black in color and slightly *magnetic*. These exist in various proportions, though the first variety may be said to predominate. Nearly all of it is slightly manganiferous, and in fact the powder ore may be considered a decomposed variety of manganiferous block ore, and is often found filling up the interstices formed by the joints and cracks in the same.

As a rule the ore bodies are remarkably free from mechanical admixture or gangue, and the ore is very pure. The structure of the beds is eminently lenticular, the lenses lapping over each other longitudinally and vertically, with a general north-westerly dip varying from 70° to nearly vertical. In mining their position is traced by small stringers or leaders of ore, and by the flow of water which follows them. The hanging wall is usually a decomposed gneiss or slate, and the foot-wall a soft, black muck, which has been found to contain a considerable amount of fine black ore. The ore formation is continuous in length over the 2,400 feet, and indeed there is no proof that it does not continue still farther in either direction.

Transversely to the strike the ore bodies occupy a width varying probably from 50 to 100 feet. In the western drifts on the lower level (depth 173 feet) of shaft No. 4 a solid limestone ledge has been encountered, and this is probably the western boundary of the ore formation. As to the size of the separate lenses, they vary in thickness from less than 3 to more than 28 feet, holding out well in length and depth, though no definite figures can now be given of the latter, owing to insufficient development.

ANALYSES OF ORE FROM THE ORMOND MINE, GASTON COUNTY.

	(204a)	(204b)	(196)	(204d)	(204e)	(197)	(199)
Silica	......	......	9.72	......	......	1.55	1.51
Metallic iron	64.40	63.52	52.39	47.10	66.60	65.35	65.79
Sulphur	......	......	0.048	......	......	......	......
Phosphorus	0.036	0.033	0.079	0.057	0.019	0.007	0.028
Phosphorus ratio	**0.055**	**0.051**	0.150	0.121	**0.028**	**0.010**	**0.042**

The Little Mountain Mine is situated ¾ mile east of the Ormond mine. The country rock is a silicified slate; its strike is N. 37° E., and dip from 70° N. W. to the vertical. The character of the ore is brown hematite containing from 4 to 13 per cent. of combined water, and accordingly classified variously as turgite, goethite and limonite. The ore is probably pseudomorphous after siderite. It occurs in a bedded quartz vein, conformable to the schistosity. The vein matter consists of an admixture of crystalline quartz and pure ore in varying proportions. On the outcrop it is very lean, the quartz predominating; in depth the quartz gradually diminishes until at the bottom of the 60-foot shaft the material is nearly pure ore. The vein matter for the first 30 feet in depth is profusely mixed with quartz, and ore clean enough for shipping purposes can hardly be mined until that depth is passed; at this point the vein is 10 feet thick; at the bottom of the shaft it is also 10 feet thick of practically clean ore. In the drifts both north and south, on the 60-foot level, the thickness varies from 17 to 27 feet (so reported by the general manager).

ANALYSES OF ORE FROM THE LITTLE MOUNTAIN MINE, GASTON COUNTY.

	(207a)	(207b)	(208)	(209)
Silica	7.90	11.96	1.64	5.31
Metallic iron	53.75	52.70	61.20	58.37
Metallic manganese	......	......	0.77	3.20
Sulphur	0.011	......	0.090	0.113
Phosphorus	0.045	0.022	0.009	0.005
Phosphorus ratio	**0.083**	**0.041**	**0.015**	**0.009**

All of the analyses given show it to be a Bessemer ore, ranging from 1.42 to 11.96 per cent. silica, and from 52.70 to 61.20 per cent. metallic iron. There is a loose, pulverulent variety which is high in manganese, averaging over 3 per cent.; but by far the greater proportion will not average above 0.50 per cent. of metallic manganese.

The average grade of ore that can be mined and shipped directly, without further treatment, is probably best represented by analyses Nos. 207a and 207b. The ore will not require washing; but much of the leaner material, heavy in quartz admixture, can undoubtedly be successfully improved, by crushing and jigging, to produce a high-grade product.

The Yellow Ridge Belt has been worked in former years at the Costner, Ellison, Ferguson, Fulenwider, and Yellow Ridge mines. The country rock is a hornblende schist. Its strike is N. 20° E.; the dip being steep to the north-west. The ore is magnetite. The thickness of the ore bodies varies from less than 1 to 20 feet, averaging about 7 feet. At many points pyrites appears in depth. Some analyses show:

ANALYSES OF MAGNETITE ORE FROM THE YELLOW RIDGE BELT, GASTON COUNTY.

	(211)	(217)	(218)	(218a)	(221)	(223)
Silica	......	......	4.67	12.82	......	......
Metallic iron	52.00	54.71	67.18	57.60	37.40	57.49
Sulphur	......	......	0.11	0.016	1.50	0.100
Phosphorus	0.002	0.016	0.050	0.082	0.020	0.010
Phosphorus ratio	0.004	0.029	0.07	0.142	0.053	0.017

The ores of Crowder's and King's mountains are unimportant, as far as present explorations have shown.

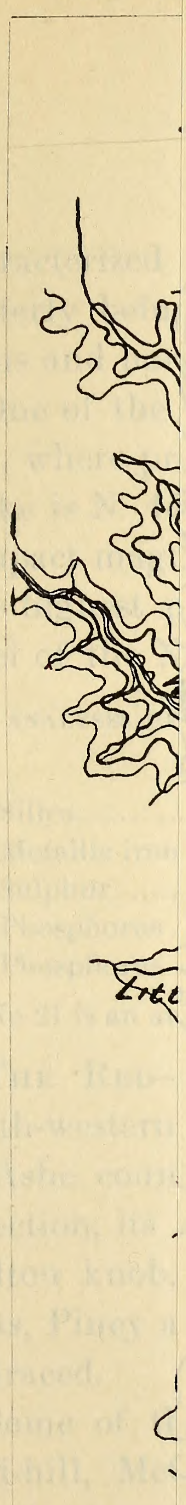
IRON ORES IN THE MOUNTAIN COUNTIES.

An important series of magnetite ore deposits occur in Ashe, Mitchell and Madison counties. These lie entirely within the zone of the crystalline schists, consisting chiefly of hornblende and mica gneisses and schists. The structure of the ore beds is lenticular, and as such they occur distributed over a rather undefinable area, though there is some regularity in the direction of their outcrops, which have a general trend north-east and south-west.

MAGNETITE ORE BELTS IN ASHE COUNTY.

In Ashe county there are three main belts, attaining their greatest development in the north-eastern portion of the county. Their location is indicated on the accompanying topographic map (Plate V). They are: 1. The Ballou or River belt. 2. The Red-hill belt. 3. The Titaniferous belt.

The Ballou or River Belt is the most easterly of the three principal ore belts, and crops out along the course of North fork of New river. There are practically two divisions of this belt, in distinct and parallel outcrops, lying about ½ mile apart, and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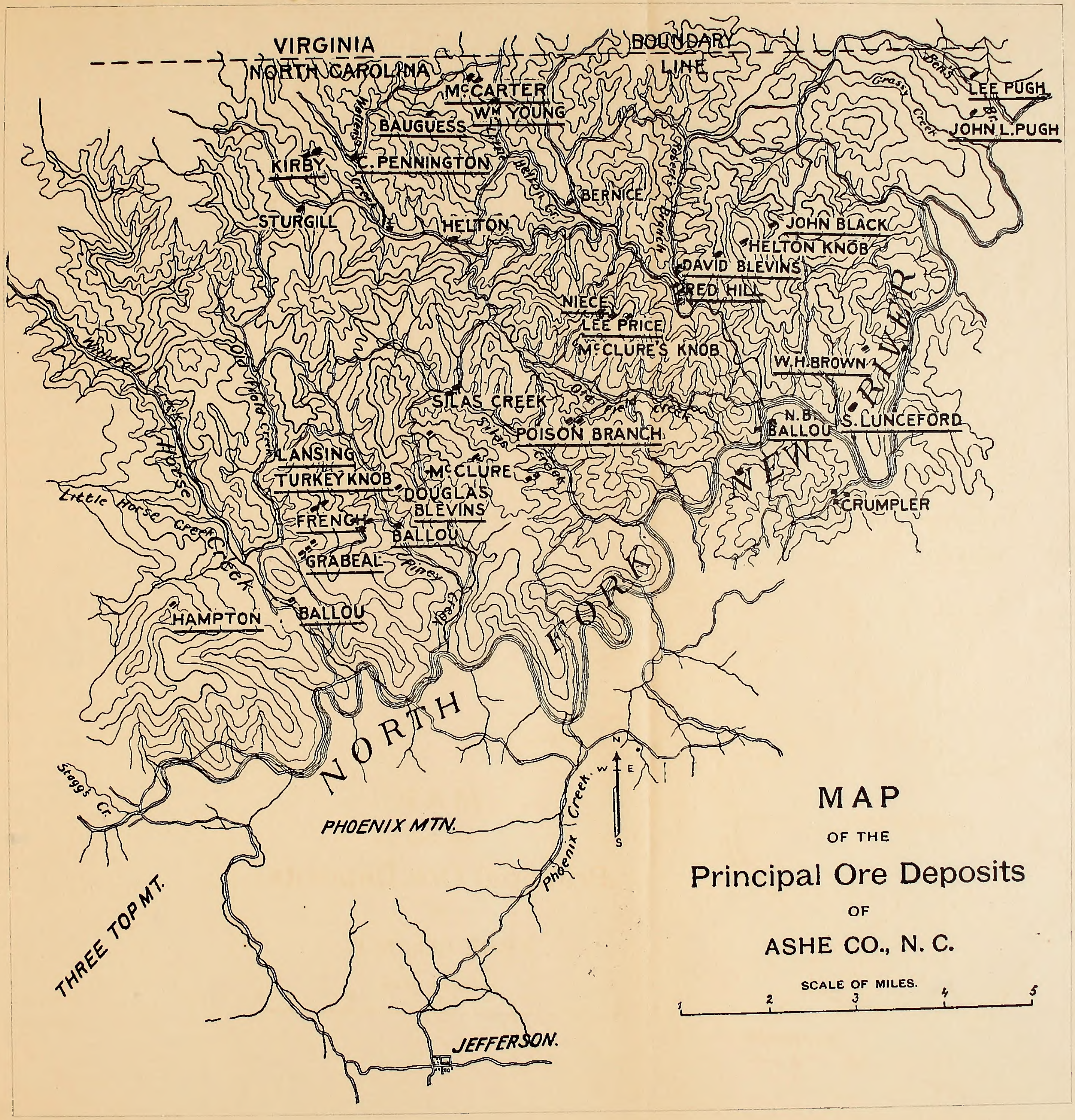

MAP
OF THE
Principal Ore Deposits
OF
ASHE CO., N. C.

characterized mainly by difference in gangue, the most north-westerly being massive hornblende-epidote, and the other micaceous and hornblende schists.

One of the most important deposits in this belt is the Ballou ore bed, where present explorations show a thickness of 12 feet. The strike is N. 45° E., and the dip is 37° S. E. The ore is a hard, compact magnetite in a gangue of hornblende, epidote and quartz. The highest point of the outcrop is probably 260 feet above the level of the North Fork of New river.

ANALYSES OF MAGNETITE ORE, N. B. BALLOU'S HOME PLACE, ASHE COUNTY.

	(19)	(20)	(21)	(22)
Silica	17.88	20.79	......	......
Metallic iron	50.68	45.50	60.81	49.06
Sulphur	0.02	0.002	......	......
Phosphorus	0.009	0.024	0.023	0.018
Phosphorus ratio	**0.017**	**0.052**	**0.037**	**0.037**

No 21 is an analysis of better selected sample of ore.

The Red-hill or Poison-branch Belt crosses from the north-western corner of Alleghany into the north-eastern corner of Ashe county, and extends thence in a general south-westerly direction, its several lines of outcrop crossing over Grassy creek, Helton knob, Red-hill, Helton creek, McClure's knob, Old Field, Silas, Piney and Horse creeks, a distance of some 10 miles as far as traced.

Some of the principal deposits are the Pugh, Black, Blevins, Red-hill, McClure's knob, Poison-branch, Piney creek, Francis, Graybeal and Horse creek. In the northern portion of the belt the ores are granular magnetites disseminated in mica and hornblende schists. The strike of the schists is N. 40° to 50° E., and the dip is 40° to 50° S. E. The ore beds are as high as 200 feet in width; and the ores are, as a rule, of Bessemer quality, though in two instances they are exceptionally high in phosphorus.

ANALYSES OF MAGNETITE ORES, ASHE COUNTY.

	(3)	(93)	(54)	(55)	(59)	(57)	(66)
Silica	22.74	21.62	19.83	32.06	21.58	11.46	12.31
Metallic iron	45.44	48.10	51.55	37.14	47.07	51.30	56.05
Sulphur	0.049	0.06	0.137	0.071	0.05	0.06	......
Phosphorus	0.022	0.036	0.042	0.004	0.07	1.12	0.071
Phosphorus ratio	**0.048**	**0.074**	**0.081**	**0.010**	0.148	2.138	0.127

Towards the south-western part of the belt the ores become manganiferous—and in places very highly so—as shown in the following analyses:

ANALYSES OF MANGANIFEROUS MAGNETITE ORES, ASHE COUNTY.

	(28)	(29)	(33)	(35)	(32)	(43)
Silica	3.12	10.64	10.82	6.09	1.73	4.58
Metallic iron	62.10	39.35	47.43	47.45	64.51	54.02
Metallic manganese	3.66	9.63	8.96	9.10	3.19	6.85
Sulphur	0.085	......	......	......	0.040	0.007
Phosphorus	0.017	0.022	0.085	0.102	0.120	0.006
Phosphorus ratio	**0.027**	**0.056**	0.180	0.215	0.186	**0.011**

The Titaniferous Ore Belt.—Starting at the northern edge of the county, near the Virginia State line, on the waters of Little Helton creek, this, the most south-westerly ore belt of importance in Ashe county, has been traced in a north-westerly direction to Helton creek, near Sturgill P. O., a distance of some 2½ miles. It is approximately 3 miles north-west of the Red-hill belt and parallel to it. The ore bodies vary from 3 to 25 feet in thickness.

ANALYSES OF TITANIFEROUS MAGNETITE ORES, ASHE COUNTY.

	(80)	(79)	(77)	(75)	(72)	(71)
Silica	5.12	5.37	9.90	6.35	4.75	17.25
Metallic iron	50.77	51.75	46.81	57.66	52.23	48.87
Sulphur	0.04	.....	0.137	0.061	0.112	0.057
Phosphorus	0.005	0.018	0.025	0.008	0.021	0.066
Titanic acid	4.950	9.170	6.030	4.690	8.910	0.210
Phosphorus ratio	**0.009**	**0.034**	**0.053**	**0.013**	**0.040**	0.135

In general the quality of the Ashe county ores is good; low in sulphur and below the Bessemer limit in phosphorus.

The mined material will, in many cases, be high in silica, but there is no reason why in such cases, by means of magnetic concentration, a high-grade product should not be obtained.

The titaniferous belt is by far the most persistent, and shows a larger quantity of ore, but the percentage of titanic acid condemns it for blast-furnace use, in competition with iron ores less difficult to smelt in the furnace.

There is little doubt that there are valuable workable beds of ore throughout the other two belts, such as Ballou's, Piney-creek, Graybeal's, Horse-creek, etc., but it will require much more extensive exploitation to define their true extent.

Nearly all of these ore deposits, being situated on the tributaries of North fork of New river, would be accessible to a railroad built up that stream, which is a feasible project.

IRON ORES IN MITCHELL COUNTY.

The principal ore deposits of Mitchell county are situated in the northern and north-western parts of the county, on the slopes of the Roan, Iron, Unaka and Pumpkin Patch mountains.

In the upheaval of the Roan and contiguous mountain ranges in Mitchell county, N. C., and Carter county, Tenn., and of the Beech mountains in Watauga county, N. C., certain dynamic causes have operated to radically deflect the position of their axes from the normal trend, and consequently the course of the ore-bearing formations over this territory has suffered similar deflections, bending in a long bow or arc from the northern part of Mitchell county at Cranberry, where the strike of the country rocks is north of west, through the southern portion of Carter county, Tenn., recrossing the State line into North Carolina, and gradually assuming its normal trend, south of west, in the western part of Mitchell county.

The principal ore deposits of Mitchell county may be divided into four belts:

(1). The Bald mountain specular belt.
(2). The Cranberry magnetite belt.
(3). The Roan mountain titaniferous magnetite belt.
(4). The Pumpkin Patch titaniferous magnetite belt.

The red hematite deposit of Bald mountain is reported to be 10 feet in thickness. The ore is fine-grained and compact; it is siliceous near the outcrop. The country rock is silicified slate, striking N. 25° E. This general belt has been traced in a south-westerly direction for 7 miles to the Toe river.

ANALYSIS OF SPECULAR HEMATITE, BALD MOUNTAIN, MITCHELL COUNTY.

	(325)
Silica	13.73
Metallic iron	52.80
Sulphur	0.06
Phosphorus	0.097
Phosphorus ratio	0.183

THE CRANBERRY MAGNETITE BELT contains by far the most important deposits of ore in this region, and has been the most extensively developed. (See Plate I, frontispiece, and Plate VI, accompanying this description).

Its eastern extremity is found at Cranberry in the northern part of Mitchell county; thence it is traced without difficulty in a direction approximately N. 34° W. for 2½ miles to the Tennessee line, which it crosses near the line of the W. N. C. and E. T. railroads; it passes through the southern portion of Carter county, Tenn., deflecting gradually westward, and thence south-westward to the headwaters of Tiger creek, recrossing into North Carolina over Iron mountain, at an elevation of nearly 4,000 feet (above sea-level), to the headwaters of Greasy creek, and continuing in a normal south-westerly direction to the Toe river, near the mouth of Pigeon Roost creek, a total distance of some 22 miles.

The most important deposit in this belt, indeed the most important in the State, is that at the Cranberry mine. It occupies the eastern slope of Cranberry ridge, the highest outcrop being 380 feet above the level of Cranberry creek. The present workings cover an area of nearly 8 acres, and consist of two tunnel openings and four main open cuts in successive levels or benches. The ore body has been explored and opened up for 875 feet in length by 300 feet in width by 275 feet maximum depth (about 165 feet average depth), representing approximately 1,600,000 cubic yards. Assuming that the gangue and ore are equally divided, half and half, and taking the specific gravity of magnetite at 5.1 and of the gangue at 3.0, this volume would contain 4,800,000 tons (gross) of ore material, of which over 3,000,000 tons are pure ore. The ore is magnetite, varying from fine to coarse granular. The gangue rock consists of hornblende, pyroxene, quartz, feldspar, epidote, calcite, garnet, allanite, zircon and serpentine. The de-

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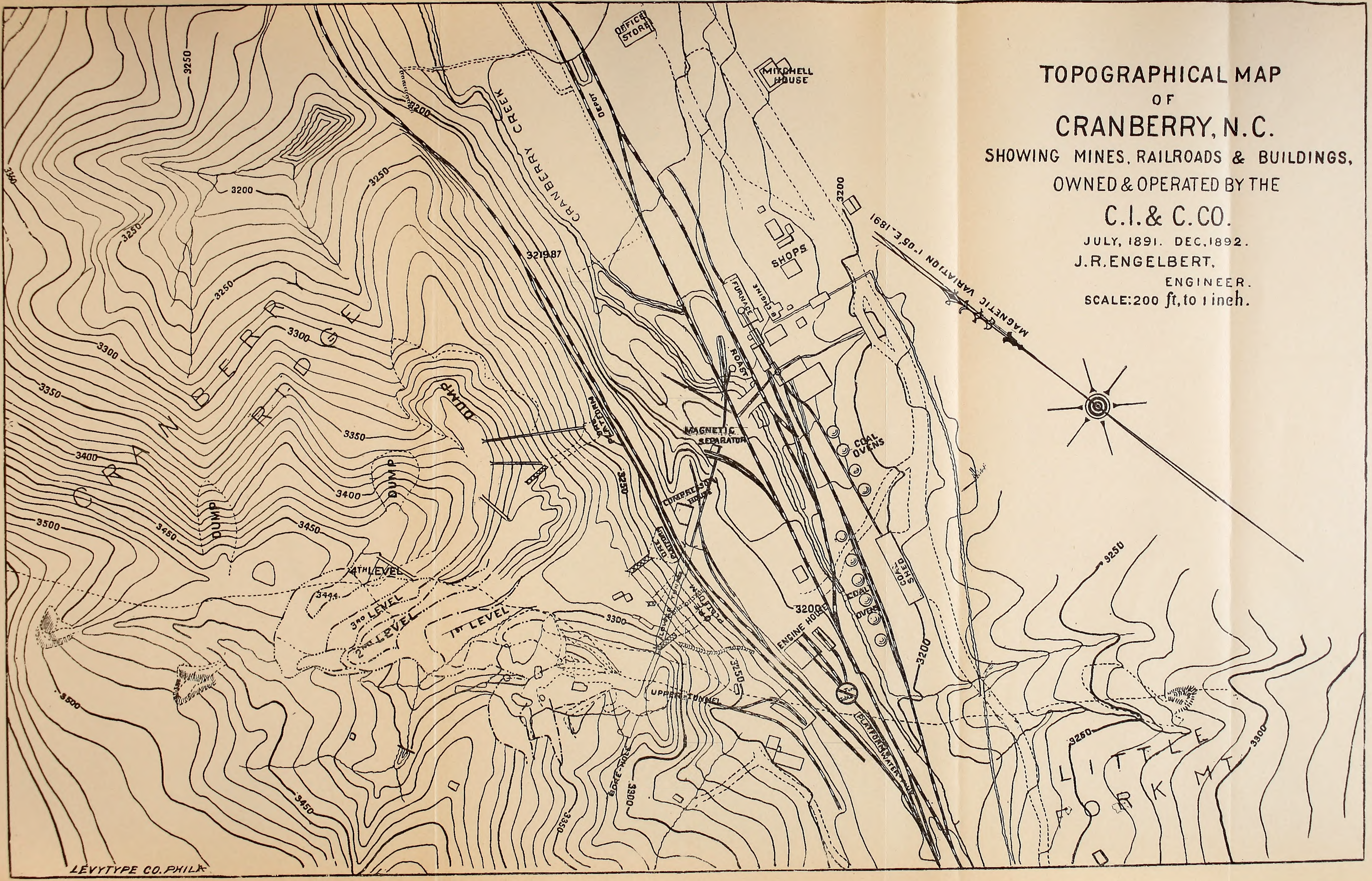


TOPOGRAPHICAL MAP
OF
CRANBERRY, N.C.
SHOWING MINES, RAILROADS & BUILDINGS,
OWNED & OPERATED BY THE
C.I. & C. CO.
JULY, 1891. DEC, 1892.
J.R. ENGELBERT,
ENGINEER.
SCALE: 200 ft, to 1 inch.

posit may be considered as one vast body of ore and rock, the ore being promiscuously distributed through the rock, but usually partaking of the form of lenses and bands. The strike is N. 34° W., and the dip 45° S. W. The country rock is gneiss.

ANALYSES OF RUN OF MINE ORE, CRANBERRY MINE, MITCHELL COUNTY.

	(292)	(293)	(294)	(295)	(298)	(311)	(312)
Silica	26.64	23.73	25.96	35.48	20.97	......	30.10
Metallic iron	42.78	45.90	44.19	34.02	45.93	44.29	32.49
Metallic manganese	0.51	0.44	0.40	......	0.31	......	......
Lime	10.80	9.69	10.62	......	10.10	......	11.37
Magnesia	1.85	1.51	1.67	......	1.43	......	1.78
Sulphur	0.023	0.012	0.041	0.047	0.020	0.129	0.128
Phosphorus	0.0064	0.007	0.008	0.013	trace.	0.007	0.010
Phosphorus ratio	**.015**	**0.015**	**0.018**	**0.039**	......	**0.016**	**0.031**

ANALYSES OF SELECTED ORE, CRANBERRY MINE, MITCHELL COUNTY.

	(310)	(313)	(314)	(315)	(316)	(317)
Silica	5.29	4.16	5.74	11.48	9.08	4.02
Metallic iron	64.87	68.34	66.22	61.98	58.49	66.53
Lime	1.47	0.43	1.01	0.72	......	1.06
Magnesia	......	0.36	0.53	0.33	......	0.23
Sulphur	0.115	.....	......	......	......	0.25
Phosphorus	0.004	......	......	......	......	trace.
Titanic acid	0.950	......	......	......	......	......
Phosphorus ratio	**.006**	......	......	......	......	trace.

The ore is concentrated on magnetic separators.

AVERAGE ANALYSIS OF FINE CONCENTRATES, CRANBERRY, MITCHELL COUNTY.

	(306)
Silica	8.33
Metallic iron	63.41
Metallic manganese	0.24
Alumina	0.41
Lime	3.12
Magnesia	0.49
Sulphur	0.045
Phosphorus	0.004
Phosphorus ratio	**0.006**

A portion of the ore is shipped to outside furnaces, while a portion is smelted in the small 15-ton furnace at the mine. The limestone for this purpose is obtained from Carter county, Tenn., and the coke from Pocahontas, Va. The average value of the shipping ore at the mine is $1.40 per ton.

ANNUAL PRODUCTION OF IRON ORE AT THE CRANBERRY MINE, MITCHELL COUNTY, IN GROSS TONS (2240 LBS.).

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
3,998	17,839	24,106	45,032	15,705	19,819	30,290	27,628	18,433

SHIPMENTS OF IRON ORE FROM THE CRANBERRY MINE, MITCHELL COUNTY, IN GROSS TONS (2240 LBS.).

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
not known.				10,129	12,974	22,873	20,284	12,088

TOTAL PRODUCTION OF PIG-IRON AT THE CRANBERRY FURNACE, IN GROSS TONS.

1884.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.
388	1,598	1,964	3,250	2,143	2,587	2,840	3,217	2,902

This iron is valued at $16 per ton at the furnace, and is shipped to furnaces and steel works in Ohio, Pittsburgh, Pa., Bethlehem, Pa., etc. Much of it is used in the manufacture of crucible tool steel. It is of a special Bessemer grade, averaging less than 1.00 per cent. silicon and less than 0.025 per cent. phosphorus.

The possibilities of the Cranberry mine as an iron ore producer have never been fairly demonstrated. The policy of the company has been rather to develop the magnitude of the deposit by slow exploratory work than to combine that very important feature with a larger output. There is no reason why this should not be made a large and steady producing iron ore mine. Operations on a large scale will also tend to reduce the cost of mining materially.

The Roan mountain and the Pumpkin Patch titaniferous belts are too insufficiently developed to warrant any special description here. The titanic acid in the ores reaches as high as 6.00 per cent.

IRON ORES IN MADISON COUNTY.

In Madison county a body of magnetite ore, resembling very much that at Cranberry, is exposed at the Big Ivy or Heck mine. This mine is situated 6 miles due north from Alexander's Station on the Western North Carolina railroad. It is on the northern slope of a hill some 285 feet above the level of Big Ivy creek. The country rock is hornblende schist, striking N. 50° E. The total thickness of the ore exposed is 52 feet.

ANALYSES OF MAGNETITE ORE, BIG IVY MINE, MADISON COUNTY.

	(286)	(287)
Silica	15.54	......
Metallic iron	48.54	42.97
Sulphur	0.012	......
Phosphorus	0.019	0.005
Phosphorus ratio	**0.039**	**0.012**

BROWN HEMATITE DEPOSITS, CHEROKEE COUNTY.

The brown hematite ore deposits of Cherokee county are among the most important in the State. The ore beds of value occur in the calc schists immediately below the quartzites and above the marble.

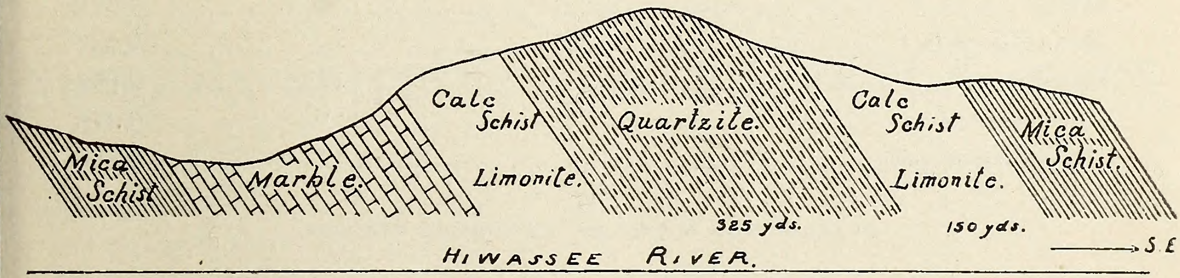


Fig. 2.—Section along Hiwassee river, showing position of iron ore.

The age of these rocks has been referred to the Lower Cambrian by Mr. Arthur Keith of the United States Geological Survey.

These ore beds are persistent and of good body and quality, though high in phosphorus. The principal deposits extend in a north-easterly direction from Murphy, the county-seat, up the valley of Valley river for a distance of some 16 miles, which may be called the *Valley River Belt*.

The ore-bearing schists continue also in a south-westerly direction from Murphy, up the valley of the Nottely river, but have not been carefully explored, and, excepting at one point, no notable deposits have yet been discovered.

South of Murphy, on the waters of Martin's creek, ore-bearing formations have been found, but only slightly explored; these are parallel ranges to the above main belt.

In the valleys of Peachtree and Low creeks, some 6 miles east of Murphy, local deposits of ore have been found, but not developed.

Beds of marble everywhere accompanying this ore, lying geologically beneath it, will furnish a convenient fluxing material.

Beds of talc, often of great purity, occur locally as lenses in the upper portions of the marble.

The Valley river belt is a double outcrop along the parallel edges of a sharp synclinal fold. These outcrops appear on both sides of a quartzite ridge, striking N. 40° E. They extend to a point near Valleytown, and have been opened at intervals all along this distance. They are everywhere accessible to the Murphy Branch of the Western North Carolina railroad. The thickness of the ore beds varies from less than 3 to more than 40 feet.

AVERAGE OF 8 ANALYSES OF SAMPLES OF VALLEY RIVER BROWN HEMATITE ORES COLLECTED BY THE N. C. G. S.

Silica	8.312
Metallic iron	54.937
Sulphur	0.055
Phosphorus	0.476
Phosphorus ratio	0.866

ANALYSES OF MARBLES, CHEROKEE COUNTY.

	(402)	(403)	(404)	(405)
Silica	2.93	0.92	1.58	1.20
Oxides of iron and aluminum	1.17	1.20	1.90	0.82
Lime	49.83	32.80	32.42	52.90
Magnesia	3.61	15.43	19.58	1.91

In the extreme western part of Madison county, south of the French Broad river, near the Tennessee State line, deposits of brown hematite and manganese ore occur, in all probability bearing geological relations to the inclosing rocks similar to the Cherokee deposits. The prospects for finding good deposits of brown hematite and manganese ore in this locality are encouraging, and the section will warrant a closer and more detailed investigation.

Similar deposits of brown hematite are reported to exist along the south-eastern slopes of the Unaka mountains, the north-western boundary of Mitchell county, and are probably an extension of this same general ore horizon.

NORTH CAROLINA GEOLOGICAL SURVEY.

NOTES ON BUILDING AND ORNAMENTAL STONE,

BY

J. V. LEWIS.

CONTENTS.

Page.

Introduction ... 61
Classification ... 62
The sandstone belt ... 63
  Anson county ... 64
    Frank Hammond quarry ... 65
    Linehan quarry ... 65
    Wadesboro Brownstone Co.'s quarry ... 66
  Moore county ... 67
    Carolina Brownstone Co.'s quarry ... 67
    Rackle and Lawrence quarry ... 68
    Co-operative Brownstone Co.'s quarry ... 70
    Region about Carthage ... 70
  Chatham county ... 71
    Egypt Coal Co.'s quarry ... 71
    Deposits near Gulf ... 72
  Wake county ... 73
  Durham county ... 73
    Duke's quarry ... 73
    Rogers quarry ... 74
    Brassfield deposits ... 74
  Orange county ... 75
    University quarry ... 75
The eastern granites and gneisses ... 75
  Vance county ... 75
    Greystone Granite and Construction Co.'s quarry ... 76
    Linehan quarry ... 76
    Other localities ... 76
  Wake county ... 77
    The Capitol quarry ... 77
    The Penitentiary quarry ... 78
    Dr. R. H. Lewis' place ... 78
    Wyatt's place ... 78
    Rolesville ... 79
  Franklin county ... 79
  Granville county ... 80
  Warren county ... 80
  Anson county ... 81
  Richmond county ... 81
  Wilson county ... 82
  Edgecombe county ... 82

PAGE.
The piedmont granite belt ... 82
  Gaston county ... 83
  Mecklenburg county ... 84
  Cabarrus county ... 85
  Iredell county ... 85
    Breed's quarry ... 86
    Johnson's quarry ... 86
    Biddell's quarry ... 87
  Rowan county ... 87
    Pink Granite Co.'s quarry ... 89
    Hambly quarry ... 89
    Stone Mountain Granite Co.'s quarry ... 90
    Kirk Mountain Granite Co.'s quarry ... 90
  Davidson county ... 91
  Davie county ... 91
  Forsyth county ... 92
  Guilford county ... 92
  Alamance county ... 93
  Surry county ... 93
    Mount Airy granite quarry ... 93
  Alexander county ... 95
Marble and other forms of limestone ... 95
  Trent river shell-rock ... 96
  Turkey cove marble deposit ... 97
  Marbles in Swain and Cherokee counties ... 98
Other ornamental and building stone ... 99
  Slates ... 99
  Serpentine ... 101
  Quartz-porphyry ("Leopardite") ... 102
  Quartzite ... 102
  Soapstone ... 103
List of building stone specimens in State Museum ... 105
Index ... 109

NOTES ON BUILDING AND ORNAMENTAL STONE.

By J. V. Lewis.

INTRODUCTION.

Stone-cutting and quarrying is one of the most recently developed industries in North Carolina, and hence its history is a short one. Except for local and special demands, no quarries were operated in the State until within the last five or six years. However, considerable quantities of stone have been obtained in a few places and small amounts quarried in many localities for such work as railroad culverts, bridge piers, street-paving and macadamizing. But, until recently, the systematic quarrying of building stone had not been undertaken.

The absence of any adequate publication or exhibit on this subject and the small demand in the Southern States for the more expensive building materials are prominent among the causes which have heretofore prevented a more thorough appreciation and development of these resources. During the past few years, however, along with advancement in other lines there has been developed in this region a small but growing demand for more permanent buildings; a lively interest has been aroused in the utilization of Southern resources; and, in North Carolina, the building stones are beginning to receive their proportionate share of attention.

The results are seen in the nine quarries now in operation in the State, employing an aggregate of nearly five hundred men and turning out over a hundred car loads of stone a week. While some of these are operated on a small scale and are still in the experimental stage, others, finding a steady demand for their products, have developed beyond that point and are enlarging their equipment and increasing their working force. A few already appear to be flourishing industries, employing from fifty to two hundred men, and are equipped with modern appliances and skilled labor.

No extensive tests have been made for hardness, specific gravity, crushing strength, or absorption, and such general information as is contained in the following notes has been obtained by brief visits to the quarries and examinations of the stone both in place and, where possible, in buildings in which it has been used.

In regard to the working qualities of the various stones, their uses and markets, and the dates of opening and closing quarries, it will be understood that the owners and quarrymen were the principal sources of information. In the main the statements are believed to be correct.

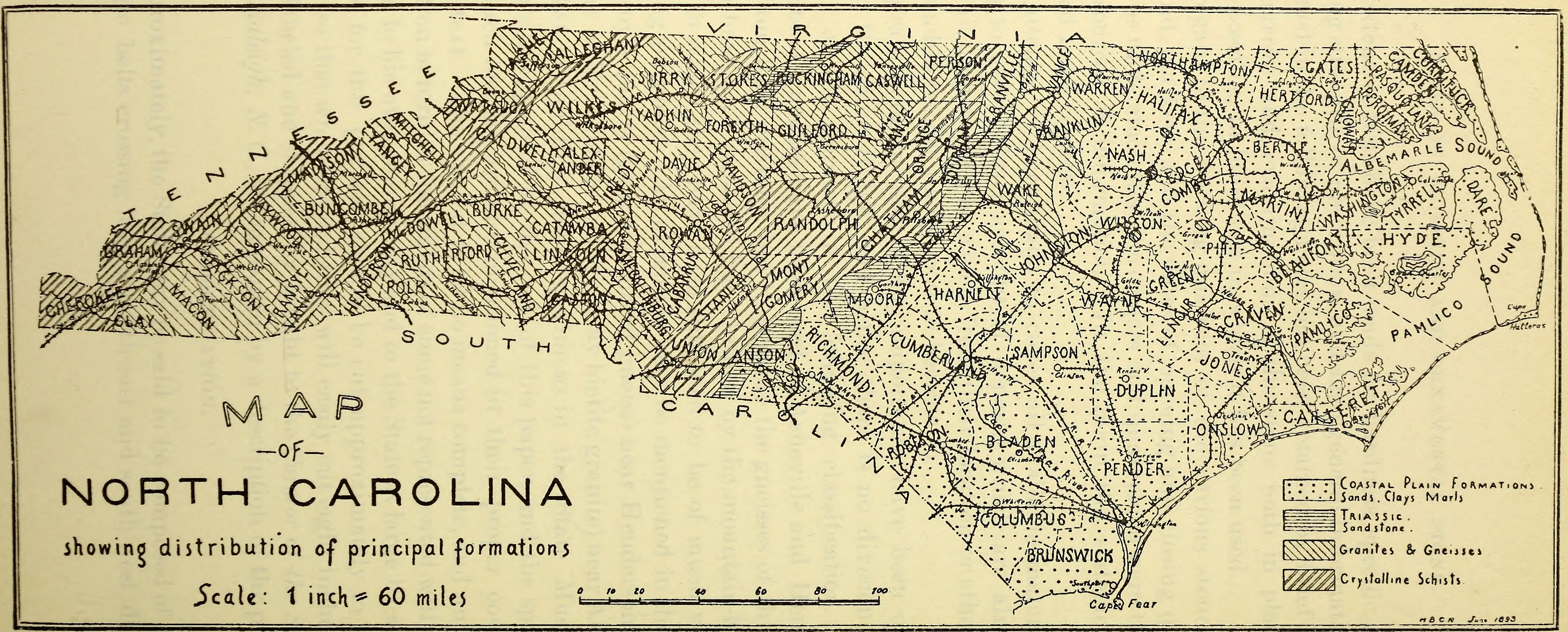
No attempt is here made to cover all available material, but simply to give a brief account of deposits which are already of economic importance, or which, from their location or other favorable conditions, are likely soon to become so.

No granites or gneisses of any importance have been quarried west of the Blue Ridge, and hence there is no division for this section of the country in the following classification. Small amounts of gneisses have been used in Asheville and Hendersonville from local quarries, but in general the gneisses of this whole region have been rendered too schistose by the mountain-building forces to which they have been subjected to be of much value for building purposes. An exception may be mentioned in the case of Mr. Troy's quarry (gray laminated gneiss) near Henderson, and in the case of Mr. Nichols' quarry (gray biotite granite) near Asheville.

A list of building stone specimens in the State Museum at Raleigh is appended at the end of this paper, and the specimens from each locality are also mentioned in their proper connection in the text. The exhibit is by no means complete, and any one in a position to furnish specimens of stone not represented will do good service to his own community and to the State at large by so doing. Blocks for this purpose should be cut approximately to ten-inch cubes (so that when dressed they will easily cut eight inches), carefully labeled and shipped by freight to the *Curator of the State Museum, Raleigh, N. C.*, accompanied by a description of the property.

CLASSIFICATION.

Approximately, the State may be said to be composed of parallel geologic belts crossing it in a north-east and south-west direction.


MAP
—OF—
NORTH CAROLINA
showing distribution of principal formations
Scale: 1 inch = 60 miles
0 10 20 40 60 80 100
Coastal Plain Formations Sands, Clays Marls
Triassic. Sandstone.
Granites & Gneisses
Crystalline Schists.
VIRGINIA
TENNESSEE
SOUTH CAROLINA
ALLEGHANY
ASHE
SURRY
STOKES
ROCKINGHAM
CASWELL
PERSON
GRANVILLE
VANCE
WARREN
NORTHAMPTON
GATES
HERTFORD
CAMDEN
CURRITUCK
PASQUOTANK
PERQUIMANS
CHOWAN
ALBEMARLE SOUND
BERTIE
WATAUGA
WILKES
YADKIN
FORSYTH
GUILFORD
ALAMANCE
ORANGE
DURHAM
FRANKLIN
HALIFAX
NASH
EDGECOMBE
MARTIN
WASHINGTON
TYRRELL
DARE
MITCHELL
YANCEY
MADISON
CALDWELL
ALEXANDER
DAVIE
DAVIDSON
WAKE
WILSON
PITT
BEAUFORT
HYDE
BUNCOMBE
McDOWELL
BURKE
CATAWBA
IREDELL
ROWAN
RANDOLPH
CHATHAM
JOHNSTON
GREENE
SWAIN
HAYWOOD
GRAHAM
JACKSON
TRANSYLVANIA
HENDERSON
RUTHERFORD
POLK
CLEVELAND
LINCOLN
GASTON
MECKLENBURG
CABARRUS
STANLEY
MONTGOMERY
MOORE
HARNETT
WAYNE
LENOIR
CRAVEN
PAMLICO
PAMLICO SOUND
Cape Hatteras
CHEROKEE
CLAY
MACON
UNION
ANSON
RICHMOND
CUMBERLAND
SAMPSON
DUPLIN
JONES
ONSLOW
CARTERET
ROBESON
BLADEN
PENDER
COLUMBUS
BRUNSWICK
Cape Fear
Wilmington
Raleigh
M B C N June 1893

Three of these belts, in the middle and piedmont regions, carry most of the stone of present economic importance and constitute the first three divisions in the following classification (see map, Plate VII):

1. THE SANDSTONE BELT, which includes the brownstones of Anson, Moore, Chatham, Wake, Durham and Orange counties—all in the Triassic formation;

2. THE EASTERN GRANITES AND GNEISSES, including the gneisses of Vance and Wake counties, the granites of Franklin, Granville and Warren; and the small areas of granite exposed by removal of the coastal plain formations in Anson, Richmond, Wilson and Edgecombe counties;

3. THE PIEDMONT GRANITE BELT consists of the granitic and syenitic rocks of Gaston, Mecklenburg, Cabarrus, Iredell, Rowan, Davidson, Davie, Forsyth, Guilford and Alamance counties, constituting the "Lower Laurentian" belt on Kerr's map, and situated along the eastern border of the central "granites and gneisses" of Plate VII. Although not closely connected with this granite belt, the Mt. Airy quarry in Surry county, and the peculiar gneiss of Taylorsville, Alexander county, forming a part of the same great central body of granites and gneisses, are considered under this head.

4. OTHER ECONOMIC STONES: slate, serpentine, quartz-porphyry, quartzite, soapstone, limestone in the eastern counties and marbles in the western counties.

THE SANDSTONE BELT.*

A line drawn on the map from Wadesboro to Henderson would be almost exactly N. 45° E. Along this line, from the southern border of Anson county and extending nearly to Oxford in Granville county, lies a belt of slates and sandstones of Triassic age which carry the coal beds of Egypt and vicinity. This belt has a maximum width of about 15 miles and extends nearly across the State. It is the same geological formation which, in Connecticut, Pennsylvania and New Jersey, furnishes the famous brownstone of our Northern and Eastern cities. In referring to this North

---

*Some of the *data* contained in these notes have already been published in the Hand-book of North Carolina, 1893, pp. 294 and 295, where, by mistake, they were credited to Mr. Geo. B. Hanna.

Carolina belt, Mr. Geo. P. Merrill, Curator of Geology in the United States National Museum, says: "The narrow belt of Triassic sandstone already mentioned as passing through this State furnishes fine, compact, light and dark reddish brownstone of a quality not at all inferior to any of that in the more northern and eastern States."*

QUARRYING.—The jointage of the Triassic formation assists very materially in quarrying, and prevents the necessity for heavy blasting, frequently dispensing to a considerable extent with blasting of any kind. Those who realize the injurious effects of blasting in sandstone will readily understand the great advantage of this.

Where the joints are not sufficiently near together the usual method is to put in light blasts and loosen large blocks, which are afterward split into dimension stone with *plugs* and *feathers* in holes along the line of the desired break. Nearly all of our sandstone has a distinct rift parallel to the bedding planes, but most of it splits equally well in either of the other two directions; in other words, it seldom shows a distinct grain. Other points in quarry practice will be mentioned as the various quarries come under consideration.

THE SANDSTONE OF ANSON COUNTY.

Within four or five years three quarries have been opened in the brownstone of this region, but none of them were in operation at the time my examination was made. The stone from all these is homogeneous, fine-grained, and quite compact. The color is reddish-brown, varying in places to grayish-brown and gray. A fine-grained specimen of light brown color from this locality may be seen in the State Museum. The average dip is about 20° south 25° east. In the compression tests given by Mr. Merrill the block from Wadesboro cracked at 8,000 pounds per square inch, and was crushed at 11,168 pounds.†

---

*Stones for Building and Decoration, page 274.

†*Ibid.*, page 412.

The chemical composition is given in the same place as follows:

Silica	69.28 per cent.
Alumina and iron oxides	13.84 " "
Magnesia	.02 " "
Potash and soda	6.43 " "

The stone here, as well as throughout the sandstone belt, hardens considerably on exposure. It works quite easily when freshly quarried, being split, dressed or carved with great facility; but blocks that have been exposed for some time to the air and sun become so refractory as to render their being worked quite impracticable. This property, which is found in many stones, is thought to be due to the evaporation of the *quarry water*, which, while remaining in the stone, holds small quantities of lime or other cementing materials in solution.

The Frank Hammond Quarry is two miles south of Wadesboro and the work done has been somewhat in the nature of prospecting, but little stone having been shipped. Except for the two miles of rather hilly road over which the stone must be hauled to the nearest shipping point, the location is quite favorable. It is in a hill-side which rises abruptly to a height of about fifty feet above a small branch. But little stripping would be necessary, and natural joints and bedding planes break the stone into small and medium-sized blocks, some of which contain as much as 75 cubic feet of workable stone.

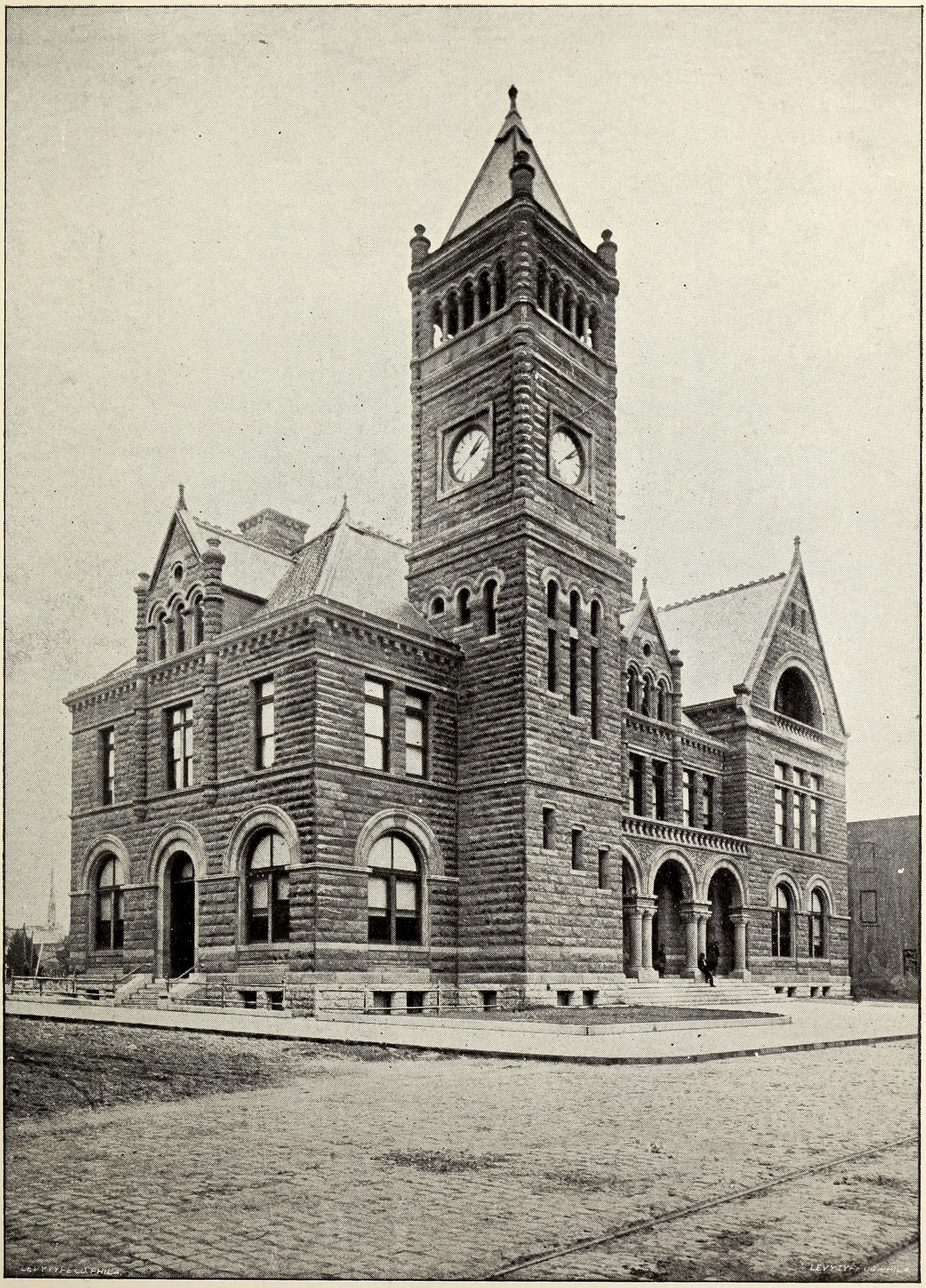
The Linehan Quarry, the property of P. Linehan, Raleigh, is one mile north of Wadesboro, near the Carolina Central railroad and connected with it by a switch. The quarry, which has been worked on a small scale, is almost entirely above water in a low hill. The present heading is about twenty feet high and two hundred feet long. The stripping is ten to twelve feet, consisting of soil and shaly, weathered sandstone. This includes several thin beds, however, which furnish some good stone. The main bed worked is about eight feet thick and is broken by rather irregular joints two to ten feet apart and following very nearly the dip and strike. The beds dip south-east about 20°, and, the quarry facing north-west, the work advances in the direction of the dip.

Blocks of five hundred cubic feet are obtainable. The stone is of fine, even grain, and fairly uniform reddish-brown color, a little brownish-gray stone appearing at one end of the quarry. Both rough and dressed stone was shipped; and two hand-power derricks were used for hoisting and loading it on the cars.

The Wadesboro Brownstone Company's Quarry is about one-fourth of a mile west of Linehan's, and one mile from Wadesboro. It, too, is connected by a switch with the Carolina Central railroad. The quarry was opened in 1887 and worked till June, 1891, a space of about one hundred by one hundred and fifty feet being excavated in a bluff about thirty feet high. It is estimated that 100,000 feet of stone was shipped. The quarry face or heading at present is about one hundred and fifty feet long and thirty feet high, most of it above water, though a good deal of work has been done below the level of the branch on account of the large amount of stripping necessary to advance into the hill. In this work a small steam pump was used to drain the quarry, and in wet weather work was frequently suspended. As much as fifteen feet stripping, consisting of soil and beds of more or less decayed stone, had to be removed in some places. Some of these beds, however, occasionally furnished workable stone. The principal work was done in beds three to eight feet thick and dipping 20° south 25° east—the direction of advance in quarrying. These beds are broken into convenient sizes for working, and blocks containing four or five hundred cubic feet are easily obtained. The prevailing color is a reddish or chocolate-brown with some stone of gray and intermediate shades. The texture is quite uniformly fine-grained, but usually somewhat coarser in the lighter colors.

A sawing plant was run in connection with the quarry, and all stone was shipped sawn or rough. Rough dimension stone was sold at seventy-five cents per cubic foot; sawn on two sides at one dollar; sawn on four sides at one dollar and twenty-five cents per foot.

Specimens of this stone may be seen in the post-office and Federal court buildings of Wilmington (Plate VIII), Asheville and Statesville; the Young Men's Christian Association buildings at Charlotte and Atlanta, and in the Garrett school building in Baltimore.



POST-OFFICE BUILDING, WILMINGTON. BROWNSTONE.

Fifty to seventy-five men were employed, and the quarry equipment consisted of two boilers and engines of about fifty-horse power each; five gangs of saws, one steam drill, one steam-power derrick of fourteen tons capacity, and two horse-power derricks.

SANDSTONE QUARRIES IN MOORE COUNTY.

Quarries near Sanford.—With one exception the brownstone of the Sanford quarries is similar to that of Wadesboro. It is not quite so hard, but the reddish-brown color and fine, even grain are much the same; perhaps the Sanford stone is a little more uniform in both. Several specimens of brown and gray and intermediate shades from this locality are on exhibit in the State Museum.

The exception above referred to is the Rackle and Lawrence quarry, which is in beds that seem to lie above those of the other quarries in the vicinity. The *data* at hand seem to show the existence of a small syncline to the south-west of Sanford and running out near the village, its axis lying north-east and south-west. If this surmise be correct, the Rackle and Lawrence quarry is very near the axis of this syncline, and therefore geologically above those at its borders. The characteristic distinction of this stone is noted in the description below.

Carolina Brownstone Company's Quarry is located about one mile north-west of Sanford, and within two hundred yards of the Cape Fear & Yadkin Valley railway, with which it is connected by a switch. This is the site of the old quarries from which stone was procured for the Confederate arsenal at Fayetteville. Blocks of the old workings are still to be seen with tool marks quite distinct and bearing no indications of decay.

This quarry was opened over a year ago and worked to a small extent. The main bed varies from seven to twelve feet in thickness, and dips 15° south 60° west. It is broken into large, irregular blocks by joints, usually perpendicular to the bedding. This greatly facilitates quarrying, and saves the stone from the shocks of heavy and frequent blasting. Two to six feet of soil over about four feet of cap-stone constitutes the stripping. A portion of the capping stone is utilized, though it is more clayey and of a deeper red color than the regular underlying bed. The main bed is of fine texture and quite compact; the color is brown and slightly reddish; a fine-grained specimen of rich chocolate color may be seen in the State Museum.

Up to the time of the visit to this quarry all stone had been shipped rough, but the company intended to enlarge the quarrying facilities and add a force of expert stone-cutters. Prices are, for promiscuous blocks, fifty cents per cubic foot; for dimension stone, sixty to eighty cents, according to size. Although it has been opened but a short time, specimens from this quarry may be seen in St. Luke's Church in Norfolk and in the court-house in Bristol, Tennessee. A chemical analysis of an average sample of this sandstone gave the following result:

ANALYSIS OF SANDSTONE, CAROLINA BROWNSTONE CO.'S QUARRY, SANFORD.

SiO_2	81.06
Al_2O_3	4.26
Fe_2O_3	8.91
MnO_2	trace.
CaO	0.85
MgO	0.43
Na_2O	2.63
K_2O	0.97
Loss on ignition	0.70

The present force at the time of examination was twenty-five men. Two horse-power derricks, hand drills and quarrying implements constituted the equipment. The capacity of the plant was given at eight to ten car loads a week.

THE RACKLE AND LAWRENCE QUARRY is about a mile southwest of Sanford and about one-fourth of a mile west of the Seaboard Air Line railroad. It is the property of J. M. Wicker, of Sanford, and was operated for two years under a lease, beginning in 1890. The construction of a short switch from the railroad would obviate most of the disadvantages which compelled the suspension of operations; namely, the necessity of hauling the stone a mile over a rough road for shipment, that of rehandling the stone and the consequent loss from breakage of fine work, and the necessity of being limited to the shipment of stone of small dimensions. A fine-grained, light brown specimen from this quarry is in the State Museum, also a specimen of medium brown color and texture presented by Mr. Wicker. The following is a chemical analysis of an average sample of the stone:

ANALYSIS OF SANDSTONE, RACKLE AND LAWRENCE QUARRY, SANFORD.

SiO_2	76.94
Al_2O_3	5.68
Fe_2O_3	9.87
CaO	0.90
MgO	1.01
MnO_2	trace.
Na_2O	3.59
K_2O	1.22
Loss on ignition	1.01

The quarry is situated in a depression near the head of a small branch which supplies water for the engine. The work that has been done is in the form of a pit, and pumps were necessary to drain the quarry; but by ditching a short distance down stream a depth of twenty or thirty feet could be worked with natural drainage. About 2,500 feet of stone were shipped while the quarry was in operation, nearly all of it being dressed at the quarry and cut by special contract. The beds vary from four to twelve feet in thickness and are somewhat irregularly broken by joints into blocks ten or twelve feet square, so that little blasting has been found necessary. The dip is about 15° south 70° west, and the stripping very thin, hardly exceeding three or four feet of loose soil. There is scarcely any sap rock or cap, but the top beds are found to be damaged sometimes by the penetration of roots, which, on decaying, bleach the rocks along their course.

As noted above, this quarry turns out a stone quite different from that of other quarries in the vicinity, and is doubtless working higher in the series. Stone of the ordinary brown color and medium fine texture is found here, but most of that worked is of a much finer texture and of a dark reddish-brown color. It is quite soft when quarried, and easily carved for trimmings and ornamental purposes, but it hardens considerably on exposure and is said to weather well, as far as tested. In some parts of the quarry considerable variation of texture is found, at times running into fine conglomerate; but the color is so uniform that these variations are scarcely noticeable except on close examination.

Examples of its use in building may be seen in the city hall of Charlotte and the post-office at Greenville, South Carolina. It has also been used to some extent in buildings of less prominence in Washington, Atlanta, Danville and Norfolk. This quarry will doubtless be extensively developed in the future.

The full force employed at the date of examination was about sixty men, including twenty skilled stone-cutters. The machinery consisted of a drill, derrick and pump—all operated by steam.

THE CO-OPERATIVE BROWNSTONE COMPANY'S QUARRY is about a mile south of Sanford, on the Raleigh and Augusta railroad and within three hundred yards of the track, with good grade for a switch. This company has not been long in existence and work has just been commenced on a small scale. The quarry is being opened in a north-west hill-side which slopes with the dip of the stone 15° north 80° west. A depth of twenty feet or more can be worked with natural drainage, and good dumping grounds are convenient. The stripping seems to be quite thin, and at present consists only of soil about three feet thick. The color, texture and other properties of this stone correspond very closely to that of the Carolina Brownstone Company, described above. A light brown, fine-grained specimen is in the State Museum.

Besides the places noted above there has been more or less prospecting done in several places in the county. The following are probably the most important of these:

The Stevens place, a half mile west of Sanford, has been prospected with a view to quarrying, in a hill-side sloping with the rock, which dips 10° north 30° east. Three core-drill borings to a depth of twenty-five to thirty feet show a good grade of light brownstone with but a thin soil covering and practically no cap.

IN THE VICINITY OF CARTHAGE several places were visited in the region west and north-west of the town, along the line of the proposed extension of the Carthage railroad. Many of these places show an excellent, fine-grained, compact red to brown sandstone, in natural outcrop, with every advantage for economic quarrying on a large scale, above water. On the property of Messrs. Grimm, McNeil and others, beginning within a half mile of the court-house, and continuing west and north-west for eight miles—entirely across the Triassic formation—are found numerous promising outcrops.

Many of them have not been prospected, but the stone may easily be examined in the natural ledges. Especially are the indications favorable for good quarry developments on the Grimm lands, in the bluffs along the south-west border of McLendon's creek. The Carthage railroad will doubtless be extended as soon as there is assurance of quarrying operations of sufficient importance. The stone in all this region is remarkably uniform in texture and color. Specimens of it may be seen in the court-house building at Carthage, where it has been subjected to severe tests. Two years after its erection in 1885 the building was burned down, and was afterwards rebuilt without replacing a single piece of the original stone, which was used for steps, window sills, column bases and porch-paving. None of these parts suffered serious injury except where masses of burning timber fell across steps or pavement, thus heating the blocks very irregularly. Some cracking and scaling resulted from this cause, but otherwise the stone all looks quite fresh and retains a good color.

In many places throughout this Triassic area stone of good brown and red colors and uniform texture may be seen in natural outcrop. Some of these have been worked a very little in almost every community for chimneys and tobacco barn flues, and many of them near the railroads will doubtless well repay further investigation.

SANDSTONE QUARRIES IN CHATHAM COUNTY.

Strictly speaking, at the time of my examination there were no quarries in Chatham county, but the developments on foot and the quality of the stone are deemed of sufficient importance to warrant their mention here.

Egypt Coal Company's Quarry, one-half a mile west of the village of Egypt, in a bluff about thirty feet high on the bank of Deep river, has been opened by a little work near the top of the bluff. This bluff extends at about the same height half a mile down the river. Between 3,000 and 4,000 feet of stone was quarried here in the fall of 1889 and still lies on the grounds, apparently unaffected by the weather. The tool marks are very distinct and the dressed surfaces are perfectly fresh. The beds dip about

12° south 55° east, and are broken by vertical joints running with the dip at distances of six to ten feet apart. The stripping consists of two to four feet of worthless cap rock or "sap" under about five feet of soil. Only small sizes were quarried, but blocks of five hundred cubic feet could easily be obtained. The color is a uniform brownish red, and the stone is fine-grained and quite compact. A slight lamination is observable in places, but most of the blocks quarried are entirely free from it. The following analysis is of an average sample of sandstone from this quarry:

ANALYSIS OF SANDSTONE, EGYPT COAL COMPANY'S QUARRY, EGYPT.

SiO_2	75.50
Al_2O_3	6.54
Fe_2O_3	10.49
MnO_2	trace.
CaO	1.17
MgO	0.81
Na_2O	3.76
K_2O	0.84
Loss on ignition	0.84

At Gulf, three miles above Egypt, on the Cape Fear & Yadkin Valley railway, on the left bank of Deep river, is a fine-grained red brown sandstone in a bluff about twenty-five feet high, the property of W. S. Russell, of Gulf. The beds are two to five feet thick, and dip away from the river 10° to 15° south, 25° east. The color varies to a lighter brown at the foot of the bluff, with some of the beds showing slight laminations. Blocks that were blasted out twenty-five years ago for local uses still present sharp edges, a good color, and show very little sign of disintegration. Just below this, on the same side of the river and constituting strata above the brownstone, is found a coarser-grained, hard, gray sandstone, used in the construction of the iron furnace at Gulf, which was built during the war, but the stone is still perfectly preserved, as far as concerns weathering.

Three specimens of gray and yellowish sandstone from near Gulf are to be seen in the State Museum, and represent deposits that will doubtless be opened up in the near future.

There are two good specimens of brownstone in the State Museum from "Taylor's quarry," Chatham county.

THE SANDSTONES OF WAKE COUNTY.

The eastern border of the Triassic belt passes through the entire length of the western side of the county, and, notwithstanding the gentle rolling nature of the topography of this region, the characteristic brownstone of the formation is found in natural outcrops in many places. Strictly speaking, it has not been quarried in the county, nor even prospected to any considerable extent, but there is probably good desirable stone to be found at various places accessible to the railroads.

SANDSTONE QUARRIES IN DURHAM COUNTY.

About Durham no quarries have been worked to any considerable extent, and places here mentioned have been opened principally to supply occasional local demands. No quarrying at all is done there now.

Duke's Quarry, the property of B. L. Duke, is located at the junction of the Belt Line with the Lynchburg & Durham railroad, and is one mile from the depot. A little work was done here in the spring of 1891 for railroad purposes, and part of the sills and lintels of the new Trinity College buildings were quarried here at the same time. It is a medium to fine-grained, reddish-brown sandstone, and is quite compact, and much of it finely laminated; the striæ being so fine as not to be visible at a distance of a few feet.

No serious effect would result from this structure if the stone is only placed in the wall as it lies in the quarry—with the bedding planes horizontal. Otherwise weathering would induce exfoliation, or scaling, which so frequently disfigures the brownstone structures of our cities. In the quarry the stone is exposed in a bluff about fifteen feet high, with a stripping of about six feet overlying the principal beds. The outcrop is visible for several hundred yards along the bluff, and the solid stone is laid bare by shallow gullies in several places almost to the top of the ridge, which rises thirty-six feet above the railroad. Blocks of any desired size may be obtained up to a thousand cubic feet. A specimen of this stone may be seen in the State Museum. The following analysis is of an average sample of stone from this quarry:

ANALYSIS OF SANDSTONE, DUKE'S QUARRY, DURHAM.

SiO_2	59.60
Al_2O_3	8.45
Fl_2O_3	7.43
MnO_2	trace.
CaO	7.25
MgO	1.14
Na_2O	6.53
K_2O	3.03
Loss on ignition	6.19

The Robert I. Rogers Quarry, property of the Durham Land and Security Company, is situated about one mile east of Durham. It was opened about ten years ago to supply a local demand for door and window sills, fronts, and trimmings. Only two beds, in a low, gentle slope near the branch, were worked, and part of the old working is now under water. It has been worked occasionally, as the local market required, ever since the opening, but no systematic quarrying has ever been done. The beds dip 12° south 60° east. The largest blocks quarried contained about two hundred cubic feet, but much larger ones might easily be obtained. Some of the stripping, which is rather heavy, might be utilized, but it is quite different in color and texture from the main beds, being very fine-grained and of deep reddish-brown color, while the principal beds are grayish-brown and of medium texture.

Two miles south-east of Durham a coarse gray stone has been worked to a small extent for sills and foundations of factories and trimmings for other buildings in Durham.

Near Brassfield, in the south-east corner of Durham county, near the North Carolina railroad, a light brown, fine-grained sandstone has been quarried to a small extent. Examples of its use in architecture may be seen in Raleigh in the building of the National Bank of Raleigh and in the steeple of Christ Church.

Two blocks of a very similar stone labeled "Brassfield?" are exhibited in the State Museum.

SANDSTONE DEPOSITS, ORANGE COUNTY.

THE "UNIVERSITY QUARRY" is located one and a half miles east of Chapel Hill, near the Raleigh road, and less than a mile from the western border of the Triassic formation. This furnished the coarse gray stone used for sills and steps in the University buildings, some of which were erected nearly a century ago. The stone is of a dark purplish-gray color and is quite hard. The quarry is in a steep bluff on the side of a trap ridge, and the color and hardness are doubtless due to some extent to the influence of the dike, which is scarcely more than twenty feet away. The beds are four to six feet thick and jointed into large blocks. The window sills in the oldest University building are almost intact. They were finished in *square drove* and the tool-marks are still distinct. Some of the old steps were removed in the summer of 1891, having worn down about half their thickness.

THE EASTERN GRANITES AND GNEISSES.

As stated in the classification, this division includes the gneisses of Vance and Wake counties; the granites of Franklin, Granville and Warren, and the small areas of granite exposed by the removal of the coastal plain formations in Anson, Richmond, Wilson and Edgecombe. With the exception of those at Greystone, Vance county, no quarries in this belt have been worked except for local purposes.

GRANITE QUARRIES IN VANCE COUNTY.

There are two quarries operated at Greystone, on the Raleigh & Gaston railroad, five miles north-east from Henderson. They are about half a mile apart and are working nearly the same grade of stone. Both are of uniform gray color, fine-grained, and good splitting quality. Both are operated principally on contract work, such as railroad bridges, street-paving, curbing, and rough foundation stones. Some dimension and dressed stone is quarried for general building purposes, but this constitutes only a small part of the business.

The Greystone Granite and Construction Company's Quarry is located about three-fourths of a mile north of Greystone station, with a switch running into the quarry. It was opened in 1889 and has been worked constantly to the present time (1892), most of the product being used in contract work in the Southern States. The opening at the time of the visit was about two hundred feet square and twenty-five feet deep, with natural drainage. The quarry is in the side of a hill which rises about twenty-five feet higher back of the present working, giving a vast amount of material available above water. The stripping varies from two to ten feet in thickness, about half of this usually consisting of loose soil. The beds* are almost horizontal and thin at the surface, while those of the bottom of the quarry attain a thickness of eight to ten feet. The joints are rather irregular and usually about ten degrees out of the vertical, but assist very materially in the quarrying. Blocks of any desirable size are obtainable. The color is uniform light gray with a pinkish cast. The texture is fine to medium, and also quite uniform; though quartz veins occur sometimes and, less frequently, segregations of black mica into irregular spots and streaks. By careful selection, however, these are usually avoided with little loss. A block of this stone is exhibited in the State Museum.

At the time that my examination was made (1892) there were about one hundred and fifteen men employed, including six skilled dressers and twenty-five paving-block men. The machinery consisted of two steam derricks and one hand-power derrick, three steam drills (one mounted on a quarry bar), and two hoisting engines of about twenty and fifty horse-power respectively.

P. Linehan & Sons' Quarry is near the depot at Greystone and is also connected by a switch with the Raleigh & Gaston railroad. The old quarry, a few hundred yards away, was opened about twenty years ago and worked for several years, but operations at the present site began only eight years ago. The opening is about two hundred and fifty by six hundred feet, and twenty-five feet deep, with natural drainage. Here, too, the beds are quite thin at the surface, but thicken to as much as fifteen feet in the bottom. The beds lie nearly horizontal and the joints have an average dip of 10° north 40° west; the latter are rather irregular, however, and are two to twelve feet apart. The stripping varies considerably, ranging from about two to fifteen feet, half soil and the rest thin beds of worthless stone. The color of the granite is gray and slightly darker than that of the Greystone Granite and Construction Company's quarry, owing to the greater abundance of black mica. The lamination is more distinct and the texture somewhat finer, but quartz veins are more frequent and sometimes six inches thick. It works well with the rift and grain, but is difficult to split across.

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*The term "beds" as used here, and in descriptions of gneisses in the following pages, is not given its strict geological significance, but should be understood in the sense of more or less uniform layers into which gneisses naturally break along the planes of schistosity.

The usual force employed is thirty to fifty men and the machinery includes (1892) three steam derricks, one drill and two hoisting engines.

OTHER PLACES in Vance county which furnish promising outcrops of stone, similar to that at Greystone, are found in the vicinity of Middleburg and Williamsboro. No quarrying has been done at these places and hence nothing definite can be said of them.

GRANITE IN WAKE COUNTY.

The State quarries in Raleigh have been worked to supply stone for the Capitol and the Penitentiary respectively.

THE "CAPITOL QUARRY" is a mile and a half east of the Statehouse and near the Federal cemetery. The stone is a light gray quartzose gneiss and has been worked occasionally for local demand from very early times, but no quarrying of importance was done till the stone for the Capitol was obtained here about 1833 to 1836. Since then it has been frequently worked for other purposes, chiefly for paving-blocks and macadam for the streets of Raleigh. The principal opening is about five hundred by seventy-five feet and thirty feet deep, at least a half million cubic feet of stone having been removed. The planes of foliation are almost horizontal, and the beds vary from six inches to five feet in thickness. No jointing is distinctly visible, but quarrying is very much facilitated by the strong *rift* and *grain*. The quarry should have been stripped to a depth of eight or ten feet, but much of this cap-stone was used in the lower portions of the Capitol building and has stood the weathering remarkably well although somewhat discolored. No serious disintegration is to be seen on the walls, but some scaling has been caused by frost at the foot of the columns of the east porch. Had only the perfectly sound, unweathered stone been used in the lower as in the upper part of the building, the absorption of moisture would hardly have been sufficient to cause scaling or serious weathering in our climate in an ordinary life-time. The frequent quartz "veins" in this stone constitute the principal objection to it. They are usually small, however, rarely exceeding two or three inches in thickness, and often curiously folded and crumpled, as may be seen in many parts of the Capitol walls. The texture is quite fine and uniform and the stone presents a good appearance in the sand-finish there used.

THE "PENITENTIARY QUARRY" is inside the enclosure and furnished stone for the foundations and walls of the prison. It was first opened in 1868 and has been worked for a variety of purposes—building, curbing, Neuse river improvements, etc. It is a hard gray gneiss of rather variable composition, being dark and micaceous in portions of the quarry, while in others it passes into a light feldspathic stone. The quarry is in the form of a pit about three hundred feet square at the surface and said to be over sixty feet deep, though now almost full of water and no longer worked.

On Dr. Lewis' farm, two miles north-west of Raleigh, is a gray, fine-grained gneiss which has been worked at intervals for foundations, curbing, flag-stone and general building purposes in Raleigh for many years. It works well in two directions; and an opening sixty by seventy-five feet has been made in a natural outcrop which is continuous for a quarter of a mile. It may be seen in one of the oldest buildings in Raleigh—Christ Church—in which it was used as sills and trimmings. No disintegration, discoloration, or other injurious effects of weathering are visible.

At Wyatt, on the Raleigh & Gaston railroad, on the property of L. R. Wyatt, a very pretty pink granite is found in outcrop, but not enough prospecting has been done to test its quality. Present indications are that there is only a limited quantity, but further investigation should be made, as it is a good stone and is well located with reference to shipping facilities.

Near Rolesville, half a mile to a mile south of the village, and about fifteen miles north-east of Raleigh, and five miles east of the Seaboard Air-Line railroad, there is a gray biotite granite with pinkish feldspar, of fairly uniform texture and medium grain, exposed over several acres of area. No extensive quarrying has been done, but the few blocks of stone that have been gotten out for local use indicate good working quality for this granite. A sample block may be seen in the State Museum.

Two miles south-east of Rolesville, on the land of S. W. Terrell, are a number of exposures of granite which is said to be similar in general character to that at Rolesville.

GRANITE IN FRANKLIN COUNTY.

There are numerous outcrops of granite and syenite in this county, especially in the eastern portion about Cedar Rock, and a good specimen of pink-colored syenite from this locality is in the State Museum. Bare exposures of such rock, several acres in extent, may be found on the lands of W. J. King and others in the vicinity.

One mile south-east of Louisburg, on Col. Ruffin's place, a fine-grained pinkish stone is reported which is said to work well.

Two or three miles north-west of Louisburg a gray granite outcrops in the form of numerous large boulders. The color and texture of the stone appear to be uniform, and the grain medium to fine. It is said to work well, but no quarrying has been done.

THE COUNTY QUARRY at Louisburg is on the left bank of Tar river, and furnished the stone for the county jail. It is a uniform, light gray granite of fine texture. The surface stone used in the jail is rather friable and frequently streaked with quartz veins, but it has stood the weathering for twenty years without apparent injury.

On the FREEMAN'S MILL PLACE near the Wake-Franklin county line, about twelve miles west of Springhope, the present terminus of the Albemarle & Raleigh railroad, and twenty miles east of Raleigh, are several exposures of gray biotite granite of fine to medium grain and fairly uniform texture. The outcrops are to be found on both sides of Moccasin creek, which is here the dividing line between Wake and Franklin counties; and the more promising points are sufficiently elevated above the creek to avoid trouble from water in quarrying, The stone appears to be free from injurious minerals, and a quarry will no doubt be opened up as soon as railroad transportation becomes available.

GRANITE IN GRANVILLE COUNTY.

A gray granite which works well is found in the vicinity of Oxford and eastward in numerous large boulders. Many of these have been split up for curbing, foundations, house trimmings and other local purposes, but no important ledges have been worked. It is of medium fine grain, light gray color, and quite compact, and would doubtless dress well in any of the usual styles of finish.

GRANITE IN WARREN COUNTY.

Warren presents natural outcrops of a light gray granite in several places, and a good typical specimen of it may be seen in the State Museum. Those of most importance from their location are to be found just north of Warren Plains, on the Raleigh & Gaston railroad, and at Warrenton. The latter place was worked in 1867–'68 for stone to build the county jail. The walls were plastered, however, and only the window sills left exposed. These show no perceptible change. It is a uniform fine-grained gray granite, and is exposed in several places on a gentle slope west of the town. The small grains or crystals of pyrite found scatteringly in it may cause it to stain slightly. By the aid of joints the stone used in the jail was quarried without blasting.

About one mile north of Warren Plains, on the land of Mr. W. J. Norwood, are several exposures of gray biotite granite of fine to medium grain, fairly uniform texture, and generally free from injurious minerals. The stone here has not been quarried sufficiently to indicate its working quality; and while the probabilities are in favor of this being satisfactory yet it can only be determined by actual tests.

About two miles north-west of Warren Plains is another outcrop of gray granite somewhat similar to the above, but of slightly coarser texture. A number of millstones were gotten out at this place many years ago, and several incomplete millstones are still to be seen lying on the surface. The granite here appears to have good working qualities.

Other outcrops of good stone are found in different parts of the county but at a distance from railroads, and hence they are of little immediate importance.

STONE IN ANSON COUNTY.

A very pretty mottled porphyritic *granite* occurs near Lilesville on the Carolina Central railroad. It is quite firm and compact and takes a fine polish. The colors are mottled olive-green, pink and black, and it would give beautiful effects in ornamental work.

A dark, rich olive-green *norite*, nearly black, and locally known as "black granite," is found on Jones' creek in Anson county. It takes a high polish and is a valuable ornamental stone, as will be readily seen from the blocks exhibited in the State Museum. A stone of similar nature in every respect is found north-east of this in the western border of Richmond county on a hill just beside and about forty feet above the Carolina Central railroad. It has not been used as yet, except in the construction of piers of the railroad bridge across the Pee Dee river. It is very tough and compact and probably rather too difficult to work to permit of its being used for ordinary building purposes, but its principal field of usefulness would seem to be in decorative work.

STONE IN RICHMOND COUNTY.

Three and a half miles west of Rockingham, on the Carolina Central railroad, at Hitchcock's creek, is a coarsely porphyritic *granite.* The large feldspar crystals are slightly pink in color and contain some pyrites, which is also disseminated in small quantities throughout the rock mass—enough doubtless to produce serious discoloration from weathering in exterior work. Immense boulders and ledges of it are exposed on the hill-side and in the railroad cut near the foot of the hill. It is susceptible of a high polish and has a very handsome appearance—qualities which highly recommend it for interior ornamentation. It was used to some extent in the piers of the railroad bridge across the Pee Dee river.

About four miles west of Rockingham and one-fourth of a mile from the railroad is a dark, fine-grained *norite*, locally known as "black granite," which was described above in speaking of a similar stone in Anson county.

GRANITE IN WILSON COUNTY.

A few miles south of Wilson, where the Wilmington & Weldon railroad crosses Contentnea creek, is a coarse, red, feldspathic granite of homogeneous texture, which outcrops on both sides of the creek and may be traced by natural exposures for a mile or more up stream. It splits readily and takes a good polish, and would doubtless prove valuable for ornamental if not for general building purposes. It has been used locally to a small extent, and was employed by the railroad company in the construction of bridge piers at Contentnea creek. It is broken up by a system of horizontal joints into beds three or four feet thick, and vertical joint-planes break these into large blocks. At one point on the creek the ledge rises forty feet above the water. Good specimens are in the building stone exhibit of the State Museum, and in the walls at the entrance to the Atlantic Coast-Line railroad office in Wilmington.

GRANITES IN EDGECOMBE COUNTY.

Two and a half miles above Toisnot, on the Wilmington & Weldon railroad, is a medium to coarse porphyritic granite of dark color, which has been used extensively for railroad construction, and as a curbing and building stone in Wilmington. It was also used in the foundations of the post-office building in Raleigh. In many respects it is an excellent building stone, but its working qualities are not very good.

Stone of much the same general character is found at Rocky Mount, but has been worked to only a slight extent.

THE PIEDMONT GRANITE BELT.

This division includes the granitic rocks of Gaston, Mecklenburg, Cabarrus, Iredell, Rowan, Davidson, Davie, Forsyth, Guilford and

Alamance counties; constituting Kerr's "Lower Laurentian" belt, and situated along the eastern border of the central "granites and gneisses" indicated in Plate VII of this report. Although not closely connected with this granite belt, the Mt. Airy quarry in Surry county, and the peculiar gneiss of Taylorsville, Alexander county, forming part of the same great central body of granites and gneisses, are considered under this head.

The quarries near Salisbury, Rowan county, and Mooresville, Iredell county, are the only ones now in operation in this belt. At Mooresville there are two quarries worked principally for monumental stone. Near Salisbury there are four companies at work (1892) turning out paving-blocks, curbing and macadam, but very little material for architectural purposes. No quarrying has been done in any of the other counties, except on a small scale and for purely local or special purposes. The properties of the stone in this belt are so variable that no attempt will be made at a general description.

STONE IN GASTON COUNTY.

There are only two places to be noticed in this county, and neither of these have been worked to any considerable extent. North-west of Gastonia, about two miles and a half, and about two miles south-east of Dallas, is *Peysour's quarry,* situated one mile above the point where the Chester & Lenoir railroad crosses Long creek. The granite here forms a hill or long ridge about forty feet above the creek, with extensive exposures along the top. A little stone has been taken out for monument bases and for trimmings for the court-house at Dallas. It is a rather fine-grained gray granite with a well-developed porphyritic character in places. The surface stone, which is all that has been worked, is rather friable and should be stripped off to a depth of four or five feet in quarrying.

C. L. Hope's Quarry, three miles north-west of Bellemont, is in a medium to coarse-grained light gray granite with a slight pinkish tint. It is quite hard, of uniform color and texture, and a very desirable stone for general building purposes. It is exposed for some distance on both sides of a small stream, in a bluff about twenty feet high on one side and in a gentle hill-slope on the other.

Several places have been worked a little, and altogether there have been about two hundred feet of stone quarried here. One of these places is now being worked by a small force for foundations, sills and trimmings for the new building of St. Mary's College at Bellemont. It has also been used to some extent in Charlotte for similar purposes. It is found to split very well in two directions and fairly well in the third. The following is an analysis of the granite from this quarry:

ANALYSIS OF GRANITE, HOPE'S QUARRY, GASTON COUNTY.

SiO_2	77.25
Al_2O_3	8.18
Fe_2O_3	8.17
MnO_2	1.82
CaO	0.70
MgO	0.39
Na_2O	2.05
K_2O	1.22
Loss on ignition	0.01

STONE IN MECKLENBURG COUNTY.

In this county there are two quarries, of local importance.

The city quarry at Charlotte, near the freight depot, has furnished considerable amounts of stone for paving and macadamizing the streets; but it is too variable in texture and color, and too much jointed for architectural purposes.

The Smith Quarry, four miles south of Charlotte (property of W. M. Smith, of Charlotte) is in a fine-grained hornblende granite, and is opened in a low, flat place, near a small branch, about a quarter of a mile from the railroad; but outcrops are found on the hill-side nearer the railroad and above water. Years ago millstones were quarried here for use in the primitive ore-mills for the gold mines in this and adjoining counties. In recent years it has been used frequently in small quantities by the marble workers of Charlotte for monumental purposes; and several very pretty monuments of it may now be seen in the city cemetery. Small quantities have also been used for trimming, sills and other building purposes in Charlotte. The old court-house was furnished with sills, steps and paving for porches from this quarry, and no indication of age is seen except in the wear of the pavement and steps. Some of the oldest business blocks have also more or less of this stone in their construction, but it shows no effects of weathering. It is quite hard and polishes well. The hornblende is mostly clustered into small groups of crystals, giving a speckled appearance to the polished surface. Blocks of any desired size seem to be obtainable. It is a beautiful stone and well adapted to monumental and decorative purposes, but its working qualities are not sufficiently good to permit of it being used as general building material.

The stone used in the main building of Davidson College was obtained mostly at the *Sloan mill place,* now owned by Z. A. Hovis, and situated about three and a half miles east of the College. It is a gray granite of coarse to medium-fine texture, with black mica distributed through the mass in small spots or specks. It is used in the foundations, steps and sills, and was obtained chiefly from boulders. The building was erected about 1860, and the stone has apparently suffered no injury from weathering.

Five miles south-west of Davidson College, on the *Lawson Potts place,* is a coarse white feldspathic granite, flecked with black mica. It has an extensive surface exposure and has been used to a small extent for foundations of buildings at Davidson College and Charlotte.

STONE IN CABARRUS COUNTY.

There is nothing approaching a quarry in this county, neither has there been any prospecting of importance. There are, however, outcrops of granite in many places. One of pink granite is found on the Mount Pleasant road, six miles east of Concord. It is a fine-grained, homogeneous stone of deep pink color, has very little mica and works readily. It will doubtless prove valuable as an ornamental stone. A good polished specimen is in the State Museum.

STONE IN IREDELL COUNTY.

Near Barium Springs, five miles south of Statesville, is a fine-grained dark granite, easily worked, which has been used considerably for bridge piers and other engineering work, and to a slight extent for sills and lintels in brick buildings.

At Mooresville there are three quarries, two for monumental stone, and one that has been worked to some extent for building material. There are good specimens of this stone in the State Museum.

J. N. BREED'S QUARRY, one and a half to two miles south-west of Mooresville, has been worked since 1886 for monumental stone. It is on Robert McNealy's land and is operated under a lease. The quarry was opened in 1886 and the work has been continued on a small scale to the present time (1892). It is a fine-grained, gray biotite granite, with occasional spots of coarser or darker material, which are caused by a larger proportion of black mica. These spots are avoided, however, with little waste. The quarry is in a bluff, at the foot of a small hill which rises fifteen to twenty feet higher than the present working. The heading or quarry face is about twenty-five feet high by forty feet long, and the work has advanced into the hill about forty feet. The stripping is about ten feet, but some of it is stone of fair quality. A portion of the present working is below the level of the branch, and is drained by a small steam pump. The stone is jointed into nearly horizontal layers three to eight feet thick, and these are broken into large blocks by other joints nearly vertical. Blocks twenty feet long and three by three feet in cross section were seen in the quarry, and much larger ones are obtainable. It works well, splitting with true faces and edges. Thus far the quarry has been worked only for monumental stone, and most of the output has been dressed in Charlotte and shipped to various parts of the State. Its great hardness renders its working rather expensive, but it takes an excellent polish and chiseled letters for ornamental carving stand out in beautiful contrast on a polished surface.

THE JOHNSON QUARRY* is one-fourth of a mile up the branch from the last, in the same ledge of stone, and is just being opened. Some of the stone has a more speckled appearance than that of Breed's quarry, owing to the more extensive segregation of the black mica, but no other important difference is observed, and this one is doubtless only superficial. But little stripping is encountered in this place and the prospect for economic quarrying here on a large scale is good. The quarry is about one-fourth of a mile from the Atlantic, Tennessee & Ohio railroad and a branch track can be run to it without serious expense. The following is an analysis of the granite from this quarry:

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*Subsequently purchased by the Charlotte Granite Company.

ANALYSIS OF GRANITE, JOHNSON QUARRY, MOORESVILLE.

SiO_2	66.01
Al_2O_3	17.44
Fe_2O_3	5.62
MnO_2	0.23
CaO	1.44
MgO	1.11
Na_2O	5.06
K_2O	3.16
Loss on ignition	none.

Biddell's Quarry is three miles east of Mooresville and was operated for a short while, a year ago (1891), for building stone, which was hauled on wagons to Mooresville and shipped to Pennsylvania markets. Three places were opened in the sloping hill-side; but in each the stone was found rather variable in color and intersected by numerous quartz veins. There has been no systematic work done, however, and scarcely more than the surface stone has been touched. The greater part of that exposed is of good gray color and medium to fine grain; and, except for occasional pinkish patches, segregations of black mica, and the quartz veins mentioned above, it is a very desirable stone. By careful selection these could all be avoided in stone for face-work without great loss. Any of the places worked would give a good quarry face with but little stripping. A hoisting engine, steam derricks and drills are on the grounds.

GRANITE IN ROWAN COUNTY.

The principal outcrops of granite in Rowan are found in the hills and ridge known as Dunn's mountain, and its southward continuation for a distance of ten miles. At many places nine and ten miles south of Salisbury, and three or four miles east of the North Carolina railroad, the stone outcrops in broad exposures of several acres extent, and has been worked in some of these places to a small extent for foundations, street work, and window and door sills in Concord and Salisbury. One of these places, ten miles south of Salisbury, is described as a very siliceous, white granite of fine grain and good working qualities. Another, nine miles south of Salisbury, is a pinkish feldspathic granite with a system of joints which aids very materially in quarrying. A dark quartzose granite, used in the Lutheran church at Concord, is found in the *Phillips quarry* in the same vicinity. In this region is also *Basinger's millstone quarry*, a coarse, compact quartzose granite which has been used somewhat extensively for millstones and in small quantities for building purposes.

At all these places there are large outcrops, capable of furnishing immense quantities of stone without stripping. They were worked ten or twelve years ago to the extent of 5,000 to 30,000 cubic feet each; but have not been operated since, except to supply occasional small local demands.

The most important granite area in Rowan, and one of the most important in the State, is that mentioned above as the Dunn's mountain, and the adjoining ridge for two miles south. The Yadkin railroad, crossing this ridge just south of Dunn's mountain proper, has made it practicable to build switches and open quarries in almost any part of this region. Since the construction of this road four companies have been organized to work the granite in various localities; three of these are now (1892) operating quarries, and the fourth has just placed its machinery on the grounds.

With the exception of Dunn's mountain proper, all the stone of this great boss is of medium fine grain and light gray color. It is speckled with occasional small crystals of magnetite and pink feldspar; the latter in places merging into a uniform pinkish tint, as in the Kirk mountain quarry, described below. Also on Dunn's mountain the granite of the boulders which furnished the stone for the post-office building in Raleigh* (Plate IX) is of a light gray color with only a shade of pink; and at a short distance it resembles marble. But in the ledges, which outcrop extensively on the mountain, the stone is found to have a uniform light, but distinct pinkish tint. Blocks of both colors from this locality are exhibited in the State Museum.

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*The slight discoloration to be seen on the outer granite walls of this building is due to the use in its construction of large quantities of stone from surface boulders instead of from deeper ledges.

Notwithstanding these variations in the color of the stone at different places that in any single quarry is found to have a strikingly uniform color, texture and good working qualities. The boulders are said to invariably prove harder than the ledges, and the latter to improve in the ease with which they are worked on going down from the surface.

THE PINK GRANITE COMPANY owns Dunn's mountain proper and has prospected the north side of it along the foot of a steep bare ledge for a distance of one hundred and ten feet, and found the color and texture quite uniform. It is a light, flesh-colored pink granite with a grayish tint. Small crystals of magnetite are scattered through the mass. It is a beautiful stone and capable of a high polish. There are large areas of bare granite on the north, east and south sides of the mountain, the summit rising one hundred feet above the proposed quarry site. The "sap" or discolored surface rock rarely exceeds a foot in thickness and is of a gray color. The railroad crosses the ridge a mile south of this point and it is proposed to build the branch road around the side of the hill, which affords easy grade. An engine and other quarry machinery are on the grounds. The following analysis shows the general composition of the stone:

ANALYSIS OF GRANITE, PINK GRANITE CO.'S QUARRY, DUNN'S MOUNTAIN.

SiO_2	75.14
Al_2O_3	8.61
Fe_2O_3	7.49
MnO_2	trace.
CaO	0.93
MgO	0.04
Na_2O	5.82
K_2O	2.57
Loss by ignition	none.

THE HAMBLY QUARRY, property of E. B. C. Hambly, of Rockwell, Rowan county, is within a few hundred yards of the railroad and about a mile and a half south of Dunn's mountain. It is in the side of a considerable hill, and the stone is a light gray granite thinly specked with red feldspar and with the black mica more or less aggregated into small bunches, giving the stone a speckled appearance. As yet only boulders, which are plentiful and large, have been worked here, but the stone obtained from them is good. These boulders are mostly above ground and are easily split by blasting. The discoloration in them from weathering penetrates deeper—sometimes 5 or 6 feet—than in the stone of the ledges. Paving-blocks and curbing are the principal products from this quarry. Stone from this and the adjoining quarry, described next below, was used in the foundations, steps, arches and trimmings of the Presbyterian church in Salisbury. A switch connects the quarry with the Yadkin railroad.

THE STONE MOUNTAIN GRANITE COMPANY'S QUARRY is not over two hundred yards from the last, and is on top of the hill now known as Stone mountain. This, too, has a switch from the railroad and works the same character of stone as the Hambly quarry. A slight difference is noticed in the more even dissemination of the black mica. It also contains a little more of the pink feldspar. Millstones were once quarried here and shipped to various parts of the State. The present working is for rubble in a ledge fifteen feet high and thirty feet face without a joint. The quarrymen say that the granite works well for dimension stone with the rift and grain and fairly well the "hard way," but that the rift is not so good as would be expected from the facility with which it splits with the grain. It has furnished stones for trimmings in the Methodist church at Reidsville, the Associate Reform Presbyterian church at Charlotte, and the Presbyterian church at Salisbury.

KIRK MOUNTAIN GRANITE COMPANY'S QUARRY is about three-quarters of a mile south of the last, on the same ridge, and about five miles south-east of Salisbury. At present the numerous large boulders on the surface are being worked off. The only difference between this stone and that of the Hambly and Stone-mountain quarries consists in the pink feldspar being more evenly disseminated through the mass, giving a faint pinkish tint to the color. Its splitting qualities are excellent in all three directions, and long dimension stone is split almost to exact sizes with the greatest ease. About two hundred hands are employed here, and the stone is hauled three-fourths of a mile along the ridge to the railroad. In connection with this the boulders at the foot of the hill, three-quarters of a mile west, are being worked, and the total product of both places is now used in curbing and street-paving under contract.

Other places on this ridge which present outcrops more or less favorably situated are one mile north of Dunn's mountain, known as the "Flat Rock" and the "New Discovery," and between Dunn's mountain and the Yadkin railroad, known as the "Buckley place."

GRANITE IN DAVIDSON COUNTY.

The only granite of importance in Davidson county is found in the vicinity of Lexington. It has nowhere been regularly worked, or extensively opened up, but it has been quarried as needed to supply an occasional local demand. The railroad culverts in the vicinity were built of stone obtained near Lexington. It is all of a dark gray color, inclining to blue, and is said to work well.

The granite used in the foundations, steps, porch pavement, and door and window sills of the court-house was quarried on the land of Joseph Conrad and Mrs. Fritts, one to one and a half miles north of Lexington. The building was erected about 1852, burned down in 1865, and afterward rebuilt on the same foundation. The stone is still good, and, with one or two exceptions, is not badly scaled or cracked. The steps and porch pavement show no wear.

"ORBICULAR GRANITE" IN DAVIE COUNTY.

On the Yadkin river, at the Coolomee farm, property of Frank Hairston, near Fork Church post-office, is a beautiful spotted stone which has been called "orbicular granite"; and which is thus described by Mr. Merrill:* "A very peculiar granite, and one which may prove of value for ornamental purposes, occurs at Coolomee, in Davie county. The stone is composed of radiating green augites in rounded masses an inch or more in diameter, imbedded in a white or pinkish ground mass of quartz and feldspar. On a polished surface the effect is quite unique." A beautiful specimen of this stone is on exhibit in the State Museum.

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*Stones for Building and Decoration, page 207.

STONE IN FORSYTH COUNTY.

There are no quarries in Forsyth, but a few places that have received that appellation locally are worthy of brief mention.

Five miles south of Winston, on Mrs. Charles' property, is an exposure of granite of about an acre on a steep hill-side. The texture is coarse to medium fine and the color a light gray. These properties are quite uniform except for occasional streaks of black mica where the granite becomes gneissoid. The exposure extends from the foot of the hill to a height of about thirty feet, and some stone has been quarried here for curbing, sills, and other rough work in Winston and Salem.

Three miles east of Winston and a quarter of a mile south of the railroad, on the "Maston place," is a gray gneiss. It is of medium fine grain and quite uniform in texture and color. It splits well, especially with the rift and grain. The stone is bare in several places on the hill-side about fifty feet above the branch, and was worked some twenty years ago for railroad purposes to the extent of about 5,000 cubic feet. Tool-prints of the old work are still visible on blocks of stone at the quarry.

STONE IN GUILFORD COUNTY.

Guilford has no quarries, but there are several places opened for railroad construction which may be of some value.

Near Jamestown are several places, two to three miles south-east, where granite has been obtained for local purposes.

Near Brown Summit, a mile and a half south of the station and a half mile from the railroad, is a medium fine homogeneous stone which splits readily and has been used considerably in local work.

Three miles north of Friendship, on the Northwestern North Carolina railroad, is a medium fine to coarse-grained granite which has been used only in railroad work.

About one mile south-west of Summerfield, on the Cape Fear & Yadkin Valley railway is an outcrop of gray biotite granite, of medium grain and fairly uniform texture, which was worked to a small extent in 1891.

GRANITE IN ALAMANCE COUNTY.

A white granite, closely resembling marble, and of fine grain and good working qualities, is found one mile north of Burlington on Christian Iseley's place. It has been used very little, but may be seen in Mr. Iseley's house, where it is used for window and door sills. No natural outcrops are visible and nothing can be said of the extent of this stone. Another outcrop of granite is to be seen just south of Burlington.

At several places about four miles north of Burlington small quantities of granite have been quarried for window and door sills in the factories of that vicinity, but no regular quarries are worked. The stone is usually a rather coarse-grained gray granite, and generally quite uniform in texture and color, with good working qualities.

GRANITE IN SURRY COUNTY.

THE MT. AIRY QUARRY, the only one to be considered in this county, is two miles east of the town of Mt. Airy in a solid hill of granite which rises one hundred and twenty-eight feet above the railroad at its base. An area of about forty acres of rock is bare on the hill-side, and no extensive joints have yet been found in the stone. It is a medium fine-grained light gray granite, with no visible iron or other injurious accessories. The quarry is operated by the Mt. Airy Granite Company, of Greensboro. Work was begun in June, 1890, and has been steadily continued since, with an average capacity of about three hundred cubic feet per day. This is shipped rough and dressed for building purposes to Washington, Baltimore, Philadelphia and other Pennsylvania markets, and some to Southern markets. About 250,000 cubic feet of stone have been shipped to date (August, 1892). The composition of this granite is indicated by the following analysis, which shows also the absence of injurious ingredients:

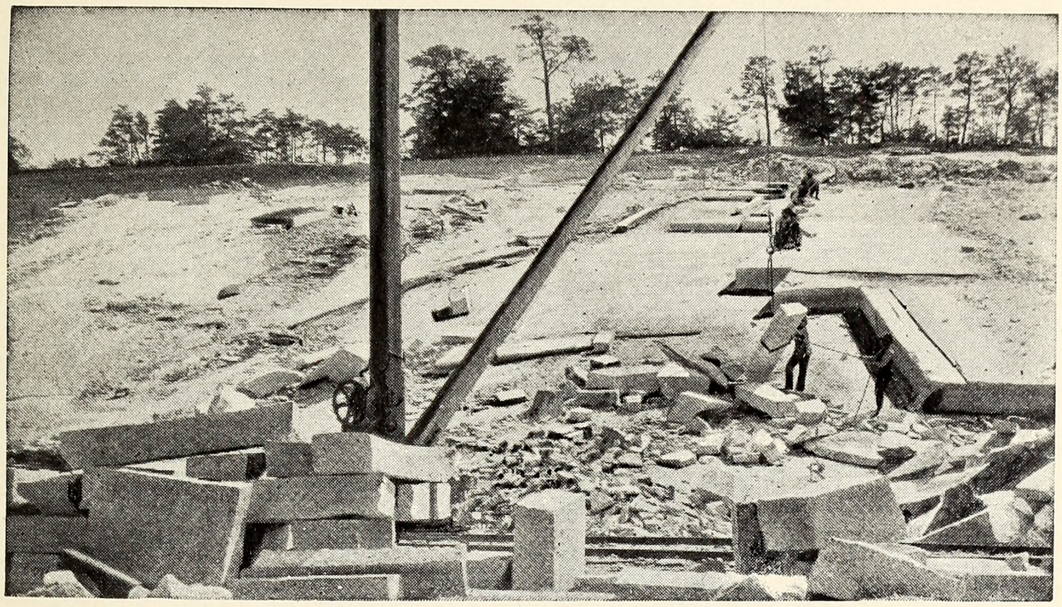
ANALYSIS OF GRANITE, MT. AIRY QUARRY.

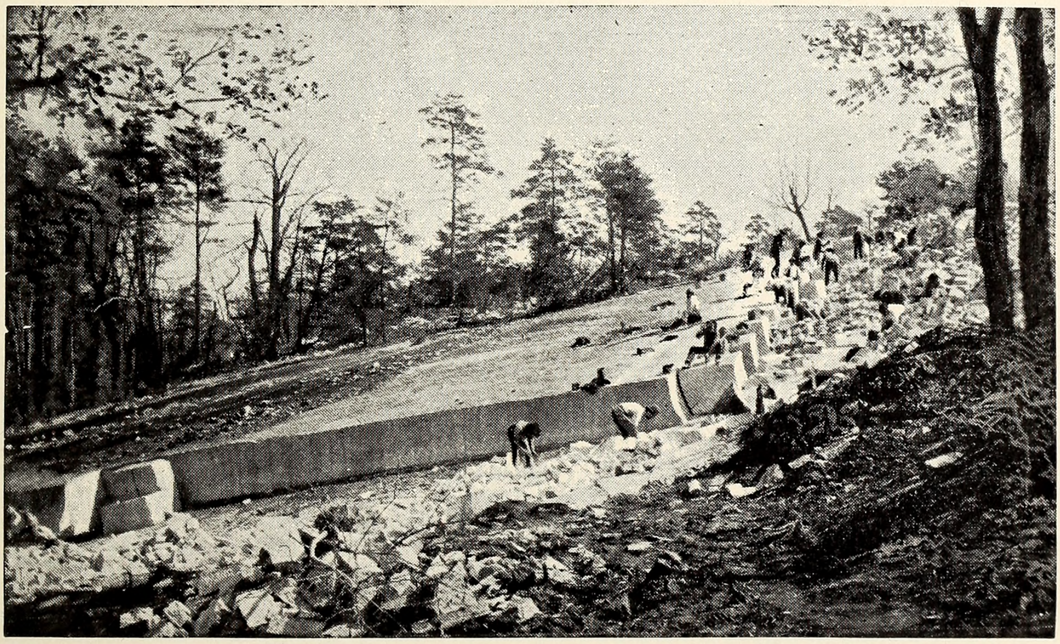
SiO_2	70.70
Al_2O_3	16.50
Fe_2O_3	2.34
FeS_2	0.093
CaO	2.96
MgO	0.29
K_2O	2.45
Na_2O	4.56

It has an excellent rift, and splits equally well with or across the grain, each being about one-third harder than the rift. The method of quarrying at the time of the visit, owing to the massive, unjointed character of the rock, was quite unique, and well illustrates the excellent working quality of the stone. No heading or quarry face was used, but work is carried on over a considerable area of bare stone on the hill slope. The method consists essentially of a hole drilled perpendicular to the surface to a depth of six to twelve feet, according to the thickness of stone desired, and then fired by a succession of light blasts, gradually increasing the charge.

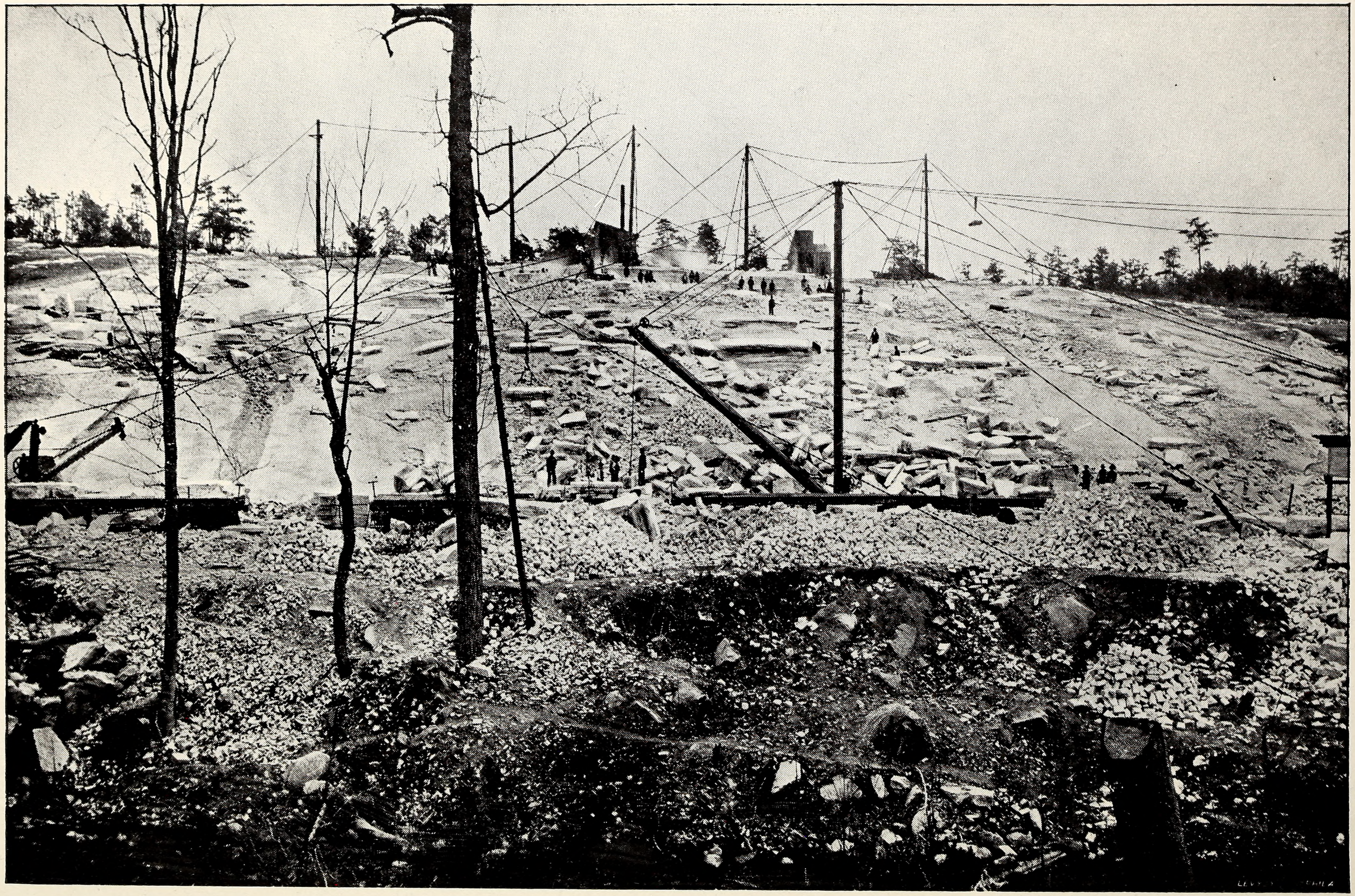
The break thus caused begins on a plane almost parallel to the surface, but gradually inclines upward with successive blasts until it finally breaks out on the surface at a distance of one hundred and fifty to two hundred feet from the center. In practice these breaks are rarely forced out by blasting. The blasting is repeated till the shell is judged, from experience, to be free almost to the edges; it is then left to break loose from the force of the strains already induced, aided by successive expansions and contractions by day and night. One or two days usually suffice to complete the break and the stone is ready to be split into any desired shapes by wedges. This is done by working inward from the margin, gradually approaching the thickest portion at the center.

Plate X shows the character of the stone and how these great "shells" are worked up; Plate XI shows the general quarry surface and the arrangement of steam derricks and the trolley system of wire ropes for moving the stone from various parts of the hill-side to the platform at the foot of the hill, where it is loaded on the cars of the Cape Fear & Yadkin Valley railway. It will be seen that the thickness gradually diminishes from the center of the loosened disk to the circumference, but in dimension stone of ordinary sizes





MOUNT AIRY GRANITE QUARRY. WORKING UP THE "SHELL."



MOUNT AIRY GRANITE QUARRY.

this variation can scarcely be detected. The increase in thickness is usually one-half to three-quarters of an inch or less to the foot, and by making the longest dimension at right angles to the radius of the disk a minimum variation is secured.

Almost the only waste in this method is at the thin edges, and the amount is very small compared with that of ordinary methods of quarrying. The stone is gathered up from various parts of the quarry and loaded on the cars by a set of tackle blocks mounted on a trolley. The largest blocks shipped weighed seventeen tons, but obviously any practicable sizes are obtainable, the limits being regulated only by the limits of the capacity for handling and transporting. There is no stripping and no loss from sap, the thickness of discolored stone not being more than an inch, and frequently less. A typical block of this granite is exhibited in the State Museum.

STONE IN ALEXANDER COUNTY.

A talcose gneiss is found at Taylorsville and has been used in the construction of a two-story building at that place. In the quarry the material is quite soft and is easily worked into any shape or size with old axes and saws, but on exposure it hardens considerably and makes a very substantial wall. The color is a brownish-red very similar to the brownstone of the Triassic region, but being schistose it is somewhat streaked. The building erected two years ago is perfectly intact and the chimneys of the same material built twenty-five years ago show no serious disintegration. It is considered fire-proof and locally is much used for hearths and fire-place linings. The building referred to was built of stone quarried on R. Z. Linney's land within a half mile of the town of Taylorsville.

MARBLE AND OTHER FORMS OF LIMESTONE.

Limestone occurs in North Carolina at a number of different localities and in a variety of forms. In the south-eastern counties it is found in many places in an uncompacted condition resembling marl; in many other places it occurs in the form commonly known as shell-rock, as may be seen at a number of points on the

North-east Cape Fear, Trent and other rivers. At still other places it occurs in the form of a fairly compact, fine-grained limestone rock, which contains, scattered through it here and there, more or less distinctly preserved shells, and this form, frequently in the same locality, changes to a typical shell-rock.

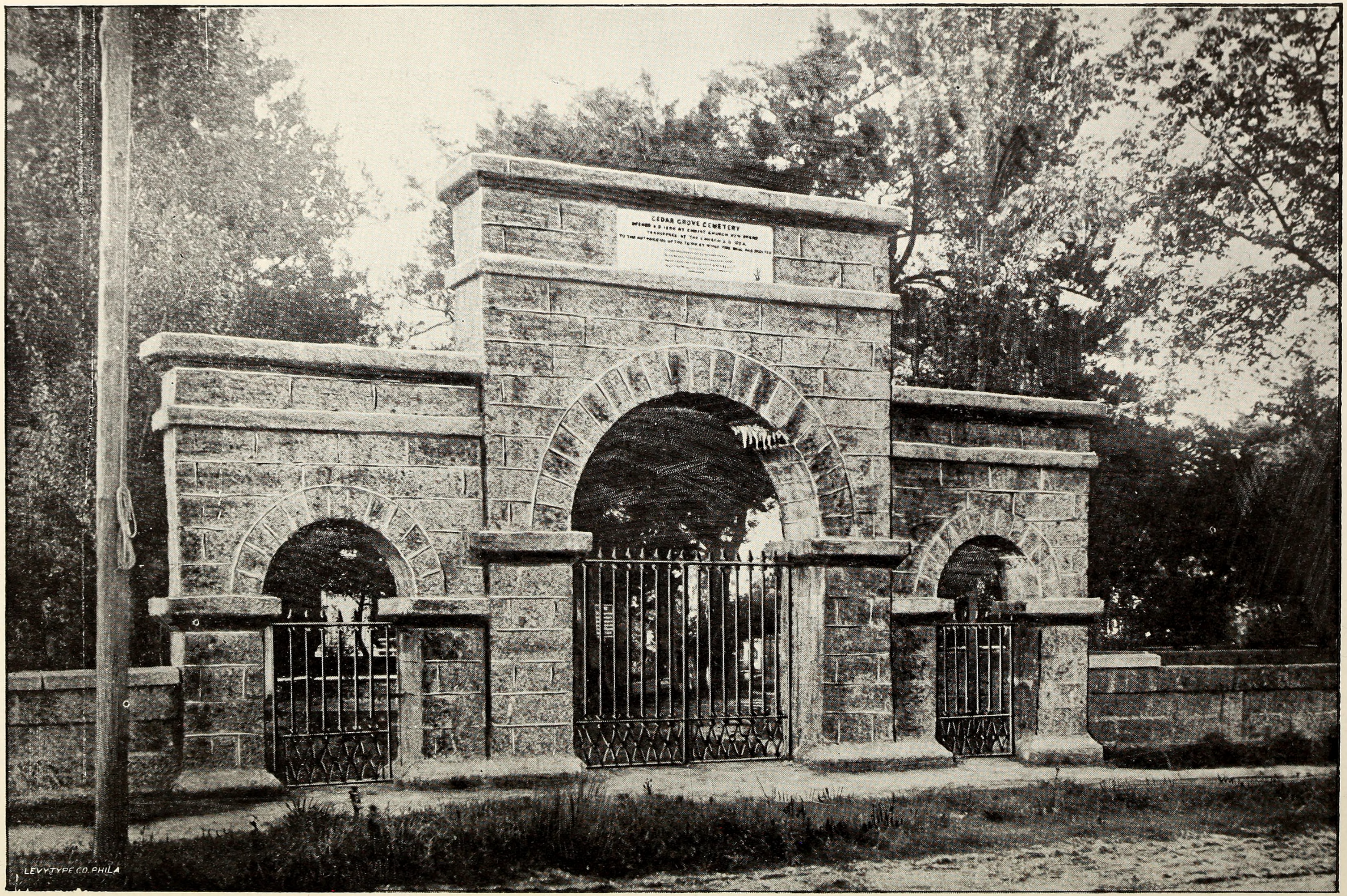
Shell limestone abounds in nearly horizontal beds in the coastal plain formations of several eastern counties, but it has been very little used as yet. It is quarried with great facility and hardens sufficiently on exposure to the air to become a very serviceable and durable stone for rough, massive work.

A shell-rock, which in places is a fairly compact limestone, and has been extensively used for harbor improvements about Wilmington, is found on the North-east Cape Fear river opposite Rocky Point and owned by Messrs. French Brothers. It is overlaid by one to five feet of soil and marl and has been worked over an area of a number of acres. This stone is also used for burning an excellent grade of agricultural lime, and in places contains small nodules of phosphate of lime.

THE TRENT RIVER SHELL-ROCK, located on Trent river, in Craven county, is a somewhat open shell-rock, used locally for rough building purposes and foundation walls. An excellent illustration of the possibilities of this stone is seen in the walls and arched gate-way of the city cemetery at Newbern, which are built of it (Plate XII). The stone is composed of medium to large size shells, with an admixture of sand, and the whole cemented together with carbonate of lime. It is a durable material, and I see no reason why it should not be used in the walls of larger buildings. It can be quarried and brought to Newbern on flats.

The shell-rock at this place, and that which occurs at Castle Haynes, Rocky Point, and other places on the river, can be used to considerable advantage in macadamizing the streets and public roads in these eastern counties, as may be seen in some of the streets of Newbern and Goldsboro paved in this way.

There are several localities in the midland and piedmont counties where there are limited deposits of a semi-crystalline limestone,—notably, those near Germantown, along the limestone belt which passes through Catawba, Lincoln and Gaston counties, and at



SHELL ROCK ARCH. ENTRANCE TO CEMETERY, NEWBERNE.

Turkey Cove, McDowell county. The limestone at this latter place, like that which occurs in the south-western counties of the State, may be properly considered a marble.

THE TURKEY COVE MARBLE DEPOSIT.

This body of marble, ten miles north of Marion, McDowell county, has been examined over an area of several hundred acres and has a thickness of more than twelve hundred feet. The beds dip at an angle of about 45° in a south-easterly direction into the north slope of Graveyard mountain. The marble is a fine-grained, compact dolomite, the color being usually nearly white, though in places it is distinctly blue, and a part of this blue marble is somewhat mottled. The general composition of the stone is shown by the following analyses:

ANALYSES OF MARBLE, TURKEY COVE, McDOWELL COUNTY.

	*WHITE MARBLE.	†BLUE MARBLE.
Silica (SiO_2)	.60	1.40
Oxides of iron and aluminum	.70	.70
Lime (CaO)	30.29	29.23
Magnesia (MgO)	21.22	19.58

These analyses show the stone to be a dolomite marble, conaining, in the case of the white marble, 54.10 per cent. of carbonate of lime ($CaCO_3$), and 44.56 per cent. of the carbonate of magnesia ($MgCO_3$). The silica (SiO_2) and the oxide of iron (Fe_2O_3) are present in quantities too small to deserve further consideration. In a few specimens, however, the percentage of silica was found to be somewhat larger. A considerable portion of the stone has been seamed and broken in connection with the dynamic changes which have occurred in the geologic history of this region, and this has greatly decreased its value as a building or ornamental stone. But the purity of the stone and its freedom from injurious ingredients will permit of this broken portion being extensively used in the manufacture of lime and cement. A large portion of the marble, as shown by the drill borings conducted under the

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*Analysis by F. P. Venable, from diamond drill borings, made by N. C. Geological Survey.

†Analysis by W. B. Phillips, Bull. 1, N. C. Geological Survey, 1893, p. 233.

supervision of the Survey, is generally free from these fractures and gashes, and is well adapted for use as a building or ornamental stone.

THE MARBLES IN SWAIN AND CHEROKEE COUNTIES.

There are considerable beds of marble occurring in Cherokee county and in that part of Swain county along the Nantahala river east of the Red Marble gap, and during the past few years these have attracted considerable attention.

The Nantahala marbles are exposed along the steep slopes of the mountain gorge on both sides of the Nantahala river, both above and below Hewitt station on the Western North Carolina railroad. The marble varies in color from nearly white to pink or flesh color and a deep bluish-gray. It is fine-grained and compact, and has been quarried to a limited extent. Two companies have been organized for the purpose of working these deposits on a larger scale.

In Cherokee county there are two or more belts of marble which appear in the south-western part of the county and extend in a general north-easterly course by way of Murphy and up the Valley river to the Red Marble gap; another parallel belt lying to the east crosses the Hiwassee river near Brasstown.

THE CULBERSON QUARRY, on the Marietta & North Georgia railroad, 11 or 12 miles south-west of Murphy, and the KINSEY QUARRY on the same railroad, five miles south-west of Murphy, have both been opened up during the past two years (1891–'92) on one of these marble belts. The stone at both these quarries is of a light gray color of fairly fine-grained and uniform texture. Its composition is shown by the following analyses, No. 1 being made from a sample from the Kinsey quarry, and No. 2 from a sample taken at the Culberson quarry:

ANALYSES OF MARBLE: KINSEY QUARRY (1), AND CULBERSON QUARRY (2).

	(1)	(2)
Silica	2.93	1.20
Oxides of iron and aluminum	1.17	.82
Lime (CaO)	49.83	52.90
Magnesia (MgO)	3.61	1.91

The marble of these belts outcrops at a number of places between the Kinsey quarry and Murphy, and between Murphy and Red Marble gap, its color and general characteristics varying at different places. At the two following points, as shown by the analyses given below, it is dolomitic in composition:

At the HAYS PLACE, near Tomotla station on the Western North Carolina railroad, 5½ miles north-east of Murphy, the marble is nearly white in color, but too much broken to be available as a building or monumental stone.

At the HICKERSON PLACE, 14½ miles north-east of Murphy, and near Andrews station on the Western North Carolina railroad, the marble is nearly white in color, fine-grained, and is of a fairly uniform texture. It has been bored into with a drill at several different places, and was found to be sufficiently solid and free from breaks and gashes to make it well suited for architectural purposes. And quarry developments may be expected here in the near future. The composition of the marble at this point and at the Hays place is shown by the following analyses:

ANALYSES OF MARBLE: HAYS PLACE (1), AND HICKERSON PLACE (2).

	(1)	(2)
Silica	.92	1.58
Oxides of iron and aluminum	1.20	1.90
Lime (CaO)	32.80	32.42
Magnesia (MgO)	15.43	19.58

Near Andrews station occurs a peculiar form of checked marble bluish-gray and white in color, the extent of which is unknown. A sample of it may be seen in the State Museum.

The outcrop of marble in the eastern part of Cherokee county, near Brasstown, is worthy of further examination. The stone is nearly white in color, of fairly uniform texture, and appears to be fairly free from breaks and gashes.

OTHER ORNAMENTAL AND BUILDING STONE.

A few notes are here appended on slate, serpentine, quartz-porphyry, quartzite and soapstone.

SLATES.

Very little has been said or known of North Carolina slates, and no systematic examination of them, from an economic point of view, has been made. The following information was gathered by personal investigation of a few localities.

In Chatham county, three miles north-west of Egypt, on Robert Burns' place, is a compact blue clay slate, exposed for a hundred yards in a gully on the hill-side. It is quite fissile, sheets of the thickness of ordinary roofing slate and eighteen inches square having been split out near the surface. No prospecting of any consequence has been done, and no confident assertion as to its value can be made. The cleavage plane dips 75° north 20° west.

Three miles west of Goldston, on Hugh Womble's place, is a slate of the same nature, but with cleavage less highly developed. It is used for chimneys and foundations in the surrounding country on account of the ease with which it splits into slabs and blocks. It would doubtless prove suitable for flagging, mantels, and other work requiring slabs, though hardly fissile enough for roofing.

On Rocky river, south-west of Pittsboro, and four miles above its junction with Deep river, near the mouth of Bear creek, is a hard blue siliceous slate, which splits well into large sheets on the outcrop, though not thin enough for roofing. The outcrop was traced up the branch for three-fourths of a mile, and numerous broad sheets were seen, which had been split off by the action of the water. The cleavage planes dip 75° south 13° east. It is the property of the Deep River Navigation Company.

In the southern edge of the county, near Fair Haven, is a hard siliceous slate of steel gray to almost black color, and having a clear, metallic ring on being struck with a hammer. A shallow ditch has been sunk across the outcrop, and blocks from near the surface are easily split into large thin sheets, well adapted to roofing purposes. The outcrop can be traced for a considerable distance on the property of George Snow, of Raleigh, and that of C. H. Womble, of Fair Haven.

In Stanly county, six miles east of Albemarle, is a dark bluish roofing slate, which is quite compact and siliceous and has a clear, metallic ring. It splits well into sheets with perfect planes, and small quantities from the prospect openings have been shaped into roofing of small and medium sizes. Large specimens of this slate are in the State Museum.

Two openings about one-fourth of a mile apart along the outcrop in the direction of the strike, and ten or twelve feet deep, have been made for testing its quality. It was found to work equally well in the two places, with small waste, notwithstanding the fact of its being near the surface. The dip of the cleavage in one opening is 77° north 26° west, in the other 67° north 46° west. The smallest blocks could be almost entirely utilized for the smaller sizes of roofing, while the larger sizes could apparently be obtained in considerable quantities. Sheets measuring two by three feet were taken from both openings.

SERPENTINE.

IN BUNCOMBE COUNTY, near Alexander station on the Western North Carolina railroad, are found numerous masses of mottled greenish-yellow to dark green serpentine. Small polished specimens from this locality may be seen in the State Museum. A belt of disconnected outcrops has been traced from near Leicester on New Found creek north-eastward across the French Broad river about a mile above Alexander, and up Reams creek nearly to Weaverville. Many of these masses are large and the quality of the stone is undoubtedly equal in every particular to that of Pennsylvania and Maryland, which is extensively used for building. Although soft and easily worked, serpentine is quite tough and resists weathering well. These properties, as well as the unique color effects, are well illustrated in several churches in Philadelphia and Baltimore which are constructed entirely of this stone. For interior ornamental work polished serpentine is a stone of great beauty and very desirable where not subjected to wear. No North Carolina serpentine has yet been quarried for building purposes, but it will doubtless come into demand in the near future.

IN MADISON COUNTY, on Paint Fork of Ivy river and in the continuation of the same belt, are numerous outcrops of serpentine which are doubtless as good as that in Buncombe county, though now too far from the railroads to be of any immediate importance.

Good specimens of serpentine are in the State Museum from

CALDWELL COUNTY, near Patterson. It is a dark rich green variety, almost black and marked by very small veins of silky chrysotile. It takes a fine polish and is well adapted to interior decorative work.

Greenish-gray serpentine, mottled with greenish and whitish chrysotile, occurs in the Baker mine, in this county, along with the coarse, fibrous variety known as picrolite.

A pale green, massive variety, mottled with yellowish veins and patches and irregular seams and grains of magnetite, occurs in WAKE COUNTY fourteen miles north-west of Raleigh, on Barton creek, in a ledge which outcrops for several hundred yards. Several specimens of this stone have been placed in the State Museum.

QUARTZ-PORPHYRY ("LEOPARDITE").

In Mecklenburg county, a mile and a half east of Charlotte, there occurs a quartz-porphyry with very peculiar manganese markings in a vertical dike ten to fifteen feet thick and traceable on the surfaces for half a mile. Mr. Merrill* describes this stone as "a very light-colored, almost white, quartz-porphyry, which is penetrated by long parallel streaks of a dead black color. These are so arranged that, when cut across, the surface appears studded thickly with roundish and very irregular black points of all sizes up to half an inch in diameter. Cut parallel with the direction of the pencils, the surface is streaked with black lines, which sometimes assume beautiful fern-like or dendritic forms.

"The rock is intensely hard, tough and without definite rift. It can therefore be worked only at great cost and is not regularly quarried."

The peculiar marking is said to decrease and finally disappear as the dike is traced northward. The stone takes a good polish and could be used with beautiful effect in inlaid work, but it is too brittle for carving. Several rough and polished specimens of this stone, and a small carved figure of a leopard, are exhibited in the State Museum.

QUARTZITE.

Near Mooresville, Iredell county, a very peculiar mottled quartzite is found. It is of a deep brownish-red color, streaked and spotted with white, and gives a very pleasing effect on polished surfaces. The great difficulty of working it into ordinary dimension stones would limit its application, but for some ornamental purposes it would seem to be very desirable.

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*Stones for Building and Decoration, pages 220 and 221.

SOAPSTONE.

Talcose rocks of the ordinary gray and bluish varieties, the only kinds used for any sort of building purposes, are found abundantly in the crystalline rocks of many counties of the State. They have been used in most of these regions for fire-places, chimneys, foundations of wooden houses and tombstones, but have nowhere been regularly quarried. Several of these places were visited, but not enough work had been done to show the quantity or quality of the stone at many of them. Hence little more than an incomplete list of localities can be given here. It is everywhere worked with axes and saws, and the ease with which it is cut is doubtless the chief reason for its very general local use.

The following are some of the localities where ordinary soapstone has been noted: Near Burlington, Alamance county; in Alleghany county, twelve miles north-east of Sparta, near Enniss post-office; on the eastern flank of Elk ridge, six to eight miles south-west of Jefferson, Ashe county—once extensively used by the Ore Knob Copper Company for furnace linings; in Watauga county, on the southern slope of Elk Knob and also near Cook's gap; in Guilford county, four miles from Greensboro, near Jamestown. The peculiar talcose gneiss of Taylorsville, Alexander county, is described above (page 95).

LIST OF SPECIMENS OF BUILDING AND ORNAMENTAL STONE IN THE GEOLOGICAL COLLECTION OF THE STATE MUSEUM AT RALEIGH.

The following is a list of the specimens of building and ornamental stone now in the geological collection of the State Museum at Raleigh. The majority of these specimens are in the form of eight-inch cubes, which have one face polished and other faces dressed in different styles to show the working qualities of the stone. The collection is by no means complete, and it is desired to add to it specimens from all portions of the State, where building and ornamental stone occurs and which are not already represented. Persons who are willing to add specimens from other localities are invited to correspond concerning the matter with the State Geologist at Raleigh. All specimens sent to the Museum in the rough should be in sizes not less than ten inches cube. In the list given below the names of the county and locality and of the donor are given, when these are known:

SANDSTONE—Anson county.
    Color light brown; grain fine.
SANDSTONE—Moore county.
    Color chocolate-brown; grain fine.
SANDSTONE—Moore county.
    Color chocolate-brown; grain fine.
SANDSTONE—Moore county.
    Color light gray; grain medium fine.
SANDSTONE—Sanford, Moore county.
    Color brownish-gray; grain medium fine.
SANDSTONE—Rackle & Lawrence quarry; Sanford, Moore county.
    Color light brown; grain fine.
SANDSTONE—Rackle & Lawrence quarry (J. M. Wicker); Sanford, Moore county.
    Color medium brown; grain medium.
SANDSTONE—Co-operative Brownstone Company's quarry; Sanford, Moore county.
    Color light brown; grain fine.
SANDSTONE—Carolina Brownstone Company's quarry; Sanford, Moore county.
    Color chocolate; grain fine.
SANDSTONE—Gulf, Chatham county.
    Color light gray; grain medium.

SANDSTONE—Gulf, Chatham county.
Color yellowish-gray; grain medium.

SANDSTONE—Gulf, Chatham county.
Color yellowish; grain coarse.

SANDSTONE—Taylor's quarry; Chatham county.
Color light brown; grain fine.

SANDSTONE—Phil. Taylor's quarry; Chatham county.
Color brown; grain medium.

SANDSTONE—Egypt, Chatham county.
Color gray-brown; grain medium fine.

SANDSTONE—Duke's quarry; Durham, Durham county.
Color light brownish-gray; grain medium fine.

SANDSTONE—Brassfield (?); Durham county.
Color light brown; grain fine.

GRANITE—Warrenton (?), Warren county.
Color very light gray; grain fine.

GRANITE, PORPHYRITIC—Lilesville, Anson county.
Color mottled pink, olive green and black; grain coarse crystalline.

GRANITE, BIOTITE—Rolesville, Wake county.
Color grayish-pink or flesh; grain medium.

GRANITE—Contentnea creek, Wilson county; P. Linehan.
Color red; grain coarse.

GRANITE—Cabarrus county.
Color pink; grain fine.

GRANITE, BIOTITE—Mooresville, Iredell county.
Color light gray; grain fine.

GRANITE, BIOTITE—Mooresville, Iredell county.
Color steel gray; grain fine.

GRANITE—Dunn's mountain, Rowan county; John L. Boyden.
Color light gray; grain medium fine.

GRANITE—Dunn's mountain, Rowan county; John L. Boyden.
Color light pink; grain medium fine.

GRANITE "ORBICULAR"—Coolomee, Davie county; Frank Hairston.
Color dark green spotted with white.

GRANITE, BIOTITE—Mount Airy Granite Co., Mount Airy, Surry county.
Color light gray; grain medium.

SYENITE—Cedar Rock, Franklin county.
Color pink; grain medium fine.

GRANITE, GNEISS—Greystone, Vance county; J. E. Stagg.
Color light gray; grain medium fine.

GNEISS—Hendersonville, Henderson county; W. B. Troy.
Color light gray; grain fine, compact laminated.

GNEISS—Alexander, Buncombe county; R. B. Vance.
Color dark gray; grain fine.

"GRANITE," NORITE—Lilesville, Anson county.
Color black; grain fine.

"GRANITE," NORITE—Lilesville, Anson county; W. H. Battle.
Color dark olive-green, nearly black; grain fine.

SERPENTINE—Alexander, Buncombe county; Jas. Foster.
Color mottled greenish-yellow (small specimen).

SERPENTINE—Patterson, Caldwell county.
Color dark green, nearly black.

SERPENTINE—Barton's creek, Wake county; Sol. Allen.
Color light green and yellowish, mottled; texture compact.

SERPENTINE—Barton's creek, Wake county; Jesse Adams.
Color mottled green and white.

QUARTZ-PORPHYRY, "LEOPARDITE"—Charlotte, Mecklenburg county.
Color spotted, black, on white ground; grain fine, dense.

QUARTZITE—Mooresville, Iredell county.
Color brownish-red, white spotted.

SHELL-ROCK—Trent river, Craven county.
Coarse open grain, of shells cemented.

SOAPSTONE—Kinsey quarry; Kinsey, Cherokee county; A. Kinsey.
Color light bluish-gray.

SOAPSTONE—Iredell county.
Color steel gray.

MARBLE—Andrews' station, Cherokee county; A. B. Andrews.
Color fine steel gray; grain fine uniform.

MARBLE—Near Valleytown, Cherokee county.
Color dark and whitish blue gray checked—unique.

MARBLE—Murphy, Cherokee county; Wm. Beale.
Color pink, gray.

MARBLE—Rickard & Hewitt's quarry; Hewitt, Swain county.
Color pink.

INDEX.

PAGE.
Alamance county, granite in........63, 93
Alexander county, stone in.........63, 95
Analyses of brown hematites......32, 33, 34, 35, 47, 56
  granites.........84, 87, 89, 94
  magnetites.....38, 39, 40, 41 43, 48, 49, 50, 53, 55
  marbles.........56, 97, 98, 99
  red hematite............34, 52
  sandstones.....65, 68, 69, 72
  titaniferous iron ores......50
Anson county, building stone in...63, 81
  sandstone of...............64
Ashe county, iron ores in.......48, 49, 50
Ashe (W. W.), investigation of forests by........................10, 12
Assays by the Geological Survey........19
Ball ores, occurrence of.......................31
Ballou mine...48
Barium Springs, granite at................85
Biddell's quarry..................................87
Big ore bank..43
Blackband ores, occurrence of......30, 31
Bog ores, occurrence of..............30, 31
Breed's (J. N.) quarry.......................86
Brassfield, sandstone near.................74
Brown hematite.....30, 32, 34, 35, 47, 55
Brownstone (see sandstone).
Buckley place quarry.........................91
Building stone, investigation of...11, 57
  specimens of in State Museum..............105
Buncombe county, granite in............62
  serpentine in......101
Cabarrus county, stone in............63, 85
Caldwell county, serpentine............102
Capitol quarry. 77
Carolina Brownstone Co.'s quarry.....67
Carthage, brownstone at...................70
Catawba county, iron ores in......36, 41, 43, 45
  limestone in...........45
Catawbarite, occurrence of...............37
Charlotte, granite at..........................84
  " Leopardite" near.........102
Chatham county, iron ores in.....31, 32, 33, 34, 35
  sandstone in..........63
  slate in................100
Chemical analyses by the Survey, 19, 20
  when made..........20
Cherokee county, iron ores in......30, 55
  marble in. 98

PAGE.
Chromic iron, occurrence of.............30
Coal investigations......................10, 16
  at Germantown....17
  Walnut cove...16, 17
Coastal plain region, investigations in..11, 12
Columbian Exposition, collections prepared for..........................15, 18, 19
Conrad (Joseph), granite owned by...91
Cook (C. E.), topography by........18, 19
Coolomee, granite at..........................91
Co-operative Brownstone Company's quarry...70
Cranberry magnetite belt..................52
  analysis of ores of..................53
Culberson marble quarry..................98
Davidson county, granite in.........63, 91
Davie county, iron ores in.................36
  "orbicular granite" in, 63, 91
Deep River Navigation Co.'s slate deposit...100
Diamond drill used by the Survey.....16
Drinking water, investigations of supplies of.....................................13, 14
Duke's quarry.....................................73
Dunn's mountain granite quarries, 87, 88, 89, 90, 91
Durham county, sandstones in.....63, 73
Expenses of the Geological Survey...21
Edgecombe county, granite in......63, 82
Egypt Coal Company's quarry..........71
Fagg (Isaac) ore bank.......................40
Flat Rock quarry.. 91
Forest products, investigation of......15
Forests, examination of.....................15
Forsyth county, building stone in..63, 92
Franklin county, granite in.........63, 79
Freeman's mill-place quarry 79
French Bros., shell-rock deposits owned by 96
Fritts (Mrs.), granite owned by.........91
Gaston county, iron ores in...36, 41, 45, 48
  stone in 63, 83
Genth (F. A.), report on minerals prepared by................16
  analyses by 39
Goethite 47
Granite, occurrence of, 63, 75, 76, 77, 78, 79, 80, 81, 82, 83 to 95

PAGE.
Granite, analyses of..........84, 87, 89, 94
Granville county, granite in........63, 80
Greystone Granite Co.'s quarry.........76
Grimm brownstone quarry..........70, 71
Gulf, brownstone at..........................72
Guilford county, stone in...........63, 92
Hairston (Frank), orbicular granite owned by..91
Hambly quarry...................................89
Hammond (Frank) quarry...............65
Harris (H. L.), investigations by......10
Hays' marble deposit.........................99
Hematite, brown..............30, 32, 47, 55
  analyses of (see analyses).
Hematite, red, occurrence of, 30, 32, 34, 51
Hickerson marble deposit....................99
Holmes (J. A.), appointed State Geologist.......................................9
  investigations by, 10, 12
Hope's (C. L.) quarry.........................83
Hovis' (Z. A.) quarry.........................85
Iredell county, stone in........63, 85, 102
Iron ore deposits in North Carolina, description of.....30, 31
  structure of........30, 31
Iron ores, investigation of...........10, 29
  in North Carolina.............30
Iron ores, titaniferous.......36, 50, 51, 54
Iseley (Christian), granite owned by..93
Johnson quarry 86
Keith (Arthur), geologic work by..19, 29
Kinsey marble quarry 98
Kirk mountain granite quarry..........90
Leopardite 102
Lewis (J. V.), investigation of building stone by................10, 11, 61
  (R. H.), granite quarry of......78
Limestone, analyses of, 45, 56, 97, 98, 99
  occurrence of.............45, 95
Lincoln county, iron ores in, 36, 41, 43, 45
  limestone in 46, 96
Limonite (see brown hematite).........46
Linehan & Sons' quarry..............65, 76
Linney (R. Z.) granite deposit. 95
List of building and ornamental stone in State Museum...........................105
Little mountain mine..................31, 47
Louisburg, granite at.........................79
Madison county, iron ores in............54
  serpentine in 101
Manganese ore.....................................56
Magnetite, mode of occurrence.....30, 42
Magnetite, occurrence of, 37, 38, 39, 40, 41, 43, 46, 48, 49, 51, 53, 54
McNealy's (Robert) quarry................86
McNeil, sandstone owned by............70
Marble, analyses of...........56, 97, 98, 99
  investigation of...................16
  occurrence of in North Carolina...........................56, 95

PAGE.
Marble and limestones..........95, 97, 98
Maston place, granite quarry on........92
Mecklenburg county, granite in........84
  leopardite in...102
Merrill, quoted 64, 91, 102
Mineral resources, investigation of....16
Miscellaneous work of North Carolina Geological Survey...........................18
Mitchell county, iron ores in, 51, 52, 53, 54
Monroe (Hersey), topography by......18
Moore county, sandstone in.........63, 67
Mooresville granite quarries.............86
Mount Airy granite quarry 63, 93
Museum, State, specimens of building and ornamental stone in 105
Nelson (William) hard ore bank.......38
  (Lee) ore bank.......................38
Nichols, quarry owned by................62
Nitze (H. B. C.), investigation of iron ores by................10
  preparation of exhibits for Columbian Exposition 19
Norite, occurrence of..................81, 82
Norwood (W. J.), granite quarries of....80
Orange county, sandstone of........63, 75
Ore Hill iron mine.......................31, 32
Ormond mine.......................................45
Ornamental stone, specimens of in State Museum...........................105
Penfield (S. L.), investigations by..10, 16
Penitentiary quarry...........................78
Pepper mine 40
Peysour's quarry.................................83
Photographic work 18
Pinchot (Gifford), a report on forest trees by..................................15
Pink Granite Company's quarry.......89
Potts' (Lawson) quarry......................85
Pratt, J. H., work in North Carolina....16
Pumpelly, R., assistance rendered by..19
Quarrying granite, Mt. Airy.............94
  sandstone..........................64
Quartzite 102
Quartz-porphyry 102
Rackle & Lawrence quarry..........67, 68
Red-hill ore belt.................................49
Richmond county, stone in..........63, 81
Rogers mine...39
Rogers quarry......................................74
Rolesville, granite near......................79
Rowan county, granite in............63, 87
Russell (W. S.), sandstone owned by...72
Salisbury, granite quarries near....87, 88
Samples for examination, directions for sending.......................20
  of stone in State Museum...105
Sandstone 63, 73–77
  hardening on exposure......65
Sandstones, analyses of...65, 68, 69, 72, 74

PAGE.
Sanford, sandstone quarries near......67
Serpentine..........101
Shell-rock deposits..........96
Siderite, occurrence of..........30
Slates..........99, 100
Smith (W. M.) quarry..........84
Snow (Geo.), slate deposit owned by..100
Soapstone..........103
Spoon (W. L.), investigations by....10, 16
Stanly county, slates of..........100
State Geologist, the work of the...17, 18
State Museum, specimens of stone in..........105
Stevens place, sandstone on..........70
Stokes county, iron ores in.....36, 37, 38
  coal in..........16, 17
Stone, building and ornamental...11, 57, 105
  specimens of in State Museum..........105
Stone mountain granite quarry..........90
Surry county, granite in..........63, 93
  iron ores in..........36, 41
Survey, geological, benefits derived from..........23
  expenses of..........21
  future work of......22
  objects of.......... 9
  organization of..... 9
  relation to private investment......21
  subjects investigated by..........10
  the law authorizing the State..... 9

PAGE.
Survey, geological, U.S. Geological, co-operation with..19
Swain county, marbles of..........98
Taylor's quarry..........63, 73
Terrell (S. W.), granite owned by......79
Titaniferous iron ores.......36, 50, 51, 54
Topographic work..........18, 19
Trent river shell-rock deposits..........96
Troy (W. B.), quarry owned by..........62
Turgite, occurrence of..........46
Turkey cove marble deposit.......... 97
United States Geological Survey, co-operation by..........18, 19
University quarry..........75
Vance county, granite in..........63, 75
Van Hise (C. R.), assistance rendered by..........19
Wadesboro, sandstone quarries at, 64, 65, 66
Wadesboro Brownstone Co.'s quarry, 66
Wake county, granites of.......63, 77, 79
  sandstones of..........63, 73
  serpentine in..........102
Warren county, granite in..........63, 80
Water, drinking, supplies of..........13
Waters, mineral, investigation of......23
Wicker (J. M.), sandstone quarry owned by..........68
Williams (G. H.), assistance by..........19
Willis (Baily), assistance by..........19
Wilson county, granite in..........82
Womble (C. H.), slate owned by.....100
Wyatt, granite at..........78
Yadkin county, iron ores in..........36, 41
Yellow Ridge iron ore belt..........48

94
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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

1893-1894

MAY 20 1775

RALEIGH:
E. M. Uzzell & Co., State Printers and Binders.
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GEOLOGICAL BOARD.

Governor Elias Carr, *ex officio Chairman*,	Raleigh.
J. Turner Morehead,	Leaksville.
S. L. Patterson,	Yadkin Valley.

J. A. Holmes, *State Geologist*,	Chapel Hill.

TABLE OF CONTENTS.

PAGE.

Letter of Transmittal 5

Report of the State Geologist 7

- Iron and Gold Investigations 7
- Corundum Investigations 8
- Forest Investigations 9
- Topographic Work 9
- Other Geologic Work 10
- Public Road Improvement 10
- Coastal Plain Work 11
- Stream Measurements 12
- Expenditures 13

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,
Raleigh, N. C., December 15, 1894.

To His Excellency, Governor Elias Carr,
Raleigh, N. C.

Sir:—I have the honor to submit for your approval and for publication the administrative biennial report of the State Geologist, covering the operations and expenditures of the Geological Survey during the two years ending November 30, 1894.

In this connection I beg to express my appreciation of the active and intelligent interest you have shown in this work throughout the past two years.

With great respect, I have the honor to remain,
Yours truly,
J. A. Holmes,
State Geologist.

BIENNIAL REPORT OF THE STATE GEOLOGIST ON THE OPERATIONS OF THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1894.

By J. A. Holmes, State Geologist.

The work of the Geological Survey during the two years ending November 30, 1894, including investigations into the gold, iron, corundum, coal and building stone deposits; the examination of the forests and forest lands of the eastern counties, with a short preliminary examination of the mountain sections; topographic surveys of certain local areas in Clay, Jackson, Macon, Orange and Stanly counties; geological investigations of the extreme western and eastern counties; and investigations relating to the occurrence of road materials in the State and methods of road construction. In this work the United States Geological Survey has co-operated with the State Survey, and this has been of considerable value.

IRON AND GOLD INVESTIGATIONS.

The iron and gold investigations have been in charge of Mr. H. B. C. Nitze, Assistant Geologist, with whom has been associated Mr. George F. Becker of the United States Geological Survey, in connection with the work on the gold deposits. The iron ore investigations, including the deposits of magnetite, hematite and limonite iron ores, in all the counties where they are known to occur, which were commenced in 1891, were completed during 1893, and the results have been published as Bulletin No. 1 of the North Carolina Geological Survey, under the title "Iron Ores of North Carolina," by Henry B. C. Nitze, containing 239 pages and 20 plates illustrating the subject.

Mr. Nitze was granted a leave of absence during the winter and early spring months of 1894 in order that he might, in conjunction with the late Dr. George H. Williams in the Geological Laboratory of the Johns Hopkins University, investigate the crystalline rocks

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of the Cranberry iron ore region. His work has important economic bearings upon the origin and nature of the Cranberry iron ores. During this time Mr. Nitze was paid no salary by the Geological Survey. He returned to North Carolina on May 12, 1894, and at once began a preliminary field examination of the central gold belts. Late in June he went to the Brindletown region of Burke county and spent the four months following in examining the gold monazite deposits of the South Mountain region in Burke, McDowell, Cleveland and Rutherford counties. During November, in company with Mr. George F. Becker of the United States Geological Survey, he made a hurried examination of the gold belt in the midland counties, and of the Portis mine region of Nash and Halifax counties.

In connection with the gold investigations, Mr. George F. Becker of the United States Geological Survey, and his assistant, Mr. Purinton, came to Charlotte in July, 1904, there arranging a camping outfit, traversed the gold region of the Piedmont counties, thence through Transylvania and other southwestern mountain counties. Later they returned to Charlotte, where during the month of November they were joined by Mr. Nitze and the party made a preliminary examination of the principal gold mines of the midland counties, and in the Nash-Halifax region about the Portis mine.

CORUNDUM INVESTIGATIONS.

The investigation of the corundum deposits has been carried on by Mr. J. V. Lewis, through a field extending from Watauga county south into Georgia, the most important deposit being in Macon and Jackson counties. Dr. George H. Williams of Johns Hopkins University and of the United States Geological Survey, spent two months during the summer of 1893 in the field with Mr. Lewis. During the winter months of 1894, Mr. Lewis made at the laboratories of Johns Hopkins University a careful laboratory examination of the rocks associated with corundum. About the middle of May he resumed the field explorations in Clay, Macon and Jackson counties, and extended the exploration northward through Haywood, Buncombe, Yancey, Mitchell, Watauga and into Ashe county. He was supplied with a traveling outfit consisting of a horse, buckboard and saddle. These investigations will be continued during 1895, and it is expected that a bulletin on this subject will be ready for publication the latter part of that year.

FOREST INVESTIGATIONS.

Mr. W. W. Ashe, Assistant in charge of the Forestry Investigations, during the winter and early spring months of 1894 continued the examination of the forest and forest lands of the eastern counties, begun late in 1893. During the summer months he prepared a preliminary report on the Forests, Forest Lands and Forest Products of Eastern North Carolina; Bulletin No. 5 of the North Carolina Geological Survey, 128 pages and 5 plates. He also aided Mr. Gifford Pinchot in the preparation of another preliminary report on the forest trees of the State. He has been granted a leave of absence during the months of October and November, but returns to the work of the Survey in December.

Prof. F. P. Venable, assisted by Mr. Charles Baskerville, has continued to do the chemical work of the Geological Survey, consisting during the present year largely of assays of gold and silver ores.

TOPOGRAPHIC WORK.

Mr. T. R. Foust, aided by Mr. A. H. McFadyen, has at intervals done local topographic work for the Geological Survey in the southeastern part of Orange county, in the vicinity of Lockville, on the Deep river, and in the vicinity of the "Narrows" on the Yadkin river in Stanly county. In the two latter places this work has a bearing on the water-power at these points. Mr. H. Munroe assisted in the water-power investigation in May, making calculations of the areas of drainage basins of rivers west of the Blue Ridge.

Mr. Charles E. Cook, topographer of the United States Geological Survey, came to the State in June, and with two assistants, Mr. J. G. Low and Mr. J. V. Lewis, was engaged during the three months following in making special topographic maps of the important corundum region in Clay, Macon and Jackson counties. During October and November he made a careful survey of the gold and monazite regions of Burke, McDowell, Cleveland and Rutherford counties.

OTHER GEOLOGIC WORK.

Mr. Arthur Keith, Geologist of the United States Geological Survey, with one assistant and camping outfit, spent the months of the summer and autumn seasons in an examination of the general and economic geology of the southwestern mountain counties. During a porton of this time, owing to a deficiency in the government appropriation, his salary and expenses were paid by the State Survey; but during the remainder of the season both were met out of the appropriation made for this purpose by Congress. The geology of this region is exceedingly complex, and the solution of the problems it presents requires a large amount of detail work. But the value of the marble, iron ore, corundum and other mineral deposits is such as to warrant whatever expenditure may be necessary for such investigations. During the months of August, September and October, 1894, Mr. Keith was engaged in making a careful geological survey of the Murphy, Asheville and Cranberry regions.

Professor Collier Cobb of the State University was employed during the summer season in an investigation of the two sandstone belts, one from Anson to Granville counties, and the other on Dan river in Stokes county. Many valuable beds of sandstone were found, and doubtless a number of these will be opened up and quarried for building purposes. The numerous traps or diabase dikes in both these sandstone areas is our best material for road-building purposes. These dikes will also be located on the maps as available road-building material.

Prof. H. F. Osborne of Columbia College, New York, came to North Carolina in May, 1894, and, without remuneration from the Survey, co-operated with the State Geologist in making an examination of the Egypt Coal Mine. And in June following, Mr. W. D. Matthews of Columbia College assisted further in this work, without remuneration from the Survey.

PUBLIC ROAD IMPROVEMENT.

In the investigation of materials suitable for road-building purposes the State Geologist has been assisted by Messrs. W. L. Spoon, J. V. Lewis, H. B. C. Nitze and Arthur Keith, each of whom has furnished data concerning the materials suitable for this purpose found in the regions in which he has been at work. While the hard and dense black diabase of the trap dikes found crossing the sandstone and adjacent regions in middle North Carolina is undoubtedly the most durable road-building material yet found or likely to be found in the State, yet there have been found in middle and Piedmont counties—and to a less extent in the mountain counties—many ledges of stone which will be found fairly satisfactory for this purpose. In the eastern counties, and especially in the counties along the boundary between the eastern and midland sections—as in Northampton, Halifax, Franklin, Nash, Wilson, Johnston, Chatham, Harnett and Richmond—there are extensive deposits of gravel and gravelly loam which will prove of great value as a material for surfacing roads. In still other areas the coarse sands when mixed with local clays have been found to make hard and firm road surfaces. If wide tires could be generally used on all the wagons and carts of such regions, these sand-clay roads would be fairly permanent, and would require but little work for keeping them in repair. At a later date there will be published a special report embodying all available data concerning these road-building materials and how they may be used to the best advantage.

COASTAL PLAIN WORK.

The State Geologist has continued his field investigations of the geological formation of the eastern counties during the present season, more especially in the region of the Cape Fear river and its tributaries. He has also continued his examinations of the building stone deposits in the midland counties of the State. He has inaugurated an examination of the water-powers of the State, and as far as possible has co-operated with all other persons prosecuting such work for the Survey.

In examining the geological formations of the coastal plain region with reference to the possible supplies of under-ground or artesian waters, the State Geologist has followed the courses of the Roanoke, Tar and Cape Fear rivers from the fall line or head of navigation on each river to its mouth, examining and photographing the bluffs and the regions adjacent to the stream. As a result of these examinations, information has been furnished to many citizens of Eastern North Carolina as to the possibilities of their obtaining supplies of artesian water and the depth at which such waters might be obtained.

STREAM MEASUREMENTS.

A new line of work has been started during the past year, which is the investigation of the streams, in regard to the amount of water that they contain at various times throughout the year and their available water-powers. The co-operation has been obtained of the Division of Hydrography of the United States Geological Survey, and it is hoped that at an early date a bulletin can be published relating to the value and distribution of the water-powers throughout the State.

It is now proposed that through the co-operation of the State and Federal Geological Survey stations may be established at one or more points on each of the more important rivers; and that at each such station a competent observer shall be employed to measure and record the height of water in the stream each day in the year. At intervals of approximately once each month each of these stations will be visited by an engineer, who will measure accurately the volume of water in the stream at that time and place and the rate of flow of the water. From this data the volume of water flowing down the stream channel and the power it would develop for each foot of fall can be easily determined. The necessity for these frequent measurements becomes apparent when it is understood that before deciding on the development of any given water-power the capitalist must know the volume of water, and hence the power that can be depended upon at any and all seasons of the year—the minimum power at the dryest season of the dryest year, and at all other stages of the stream up to the highest flood. The data which it is proposed to obtain in the manner indicated will enable the manufacturer to determine in advance the power he may reasonably expect for each month of the year, and the extent of the supplemental steam plant he may need in order to enable him to utilize to the best advantage all the power of the stream even at ordinary high water stages.

In the office work of the Geological Survey assistance has been rendered at different times by the following persons: Mr. C. A. White and Mr. H. E. C. Bryant in general clerical work; Messrs. A. B. Kimball, M. M. Smith, J. C. Dudley and J. W. Cobb, and Misses I. L. Watson and E. Shiver served at intervals as stenographers. The names of other persons temporarily employed as office or field assistants are given in the table of amounts paid for services, given below.

In addition to this he has attended to the correspondence connected with the office, which is steadily growing in volume and importance, and has performed the ordinary executive duties connected with the prosecution of all of the work of the Survey.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and subvouchers. These are grouped together and deposited with the Governor, as nearly as practicable, at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such examination and approval the vouchers and itemized statements of expenditures are deposited with the State Auditor, where they are open to public inspection. The State Geologist gives bond in the sum of twenty-five hundred dollars; and at no time can the funds at his disposal for meeting such expenditures exceed this amount.

The accompanying statements show the expenditures of the Geological Survey for the two years ending November 30, 1894, grouped according to the subjects investigated during this time, and according to the purposes for which funds are allotted.

EXPENDITURES OF THE NORTH CAROLINA GEOLOGICAL SURVEY FOR THE TWO YEARS ENDING NOVEMBER 30, 1894, GROUPED ACCORDING TO THE SUBJECTS INVESTIGATED:*

Gold investigations	$ 1,513.18
Iron investigations	2,077.75
Corundum investigations	1,955.54
Forestry investigations	1,590.21
Building stone and general explorations	3,023.26
Chemical investigations and assays	1,133.82
Photography and explorations	800.04
Water-power and photography	383.83
Clerical assistance	752.65
Postage	193.62
Instruments, equipment and repairs	565.46
Stationery	58.38
Freight and express	226.92
State Geologist's salary	5,000.92
Miscellaneous and administrative expenses	322.05
Diamond drill operations	1,069.92
Total	$20,666.63
Less items counted twice	671.00
Total amount	$19,995.63

AMOUNTS PAID FOR SERVICES TO THE SEVERAL PERSONS CONNECTED WITH THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1894:*

J. A. Holmes, State Geologist, 2 years	$5,500.00
H. B. C. Nitze, Assistant Geologist, 15 months, at $180	2,700.00
J. V. Lewis, Assistant Geologist, at $75 per month	1,227.50
W. W. Ashe, Forester, at $65 per month	1,060.00
W. L. Spoon, Road Engineer, at $65 per month	241.67
S. F. Telfair, Secretary Geological Board	15.00
Arthur Keith, Assistant Geologist, at $5 per day	210.38
J. E. Matheney, Office Assistant, 7 days, at $2	14.00
Collier Cobb, Assistant Geologist, 47 days, at $5	235.00
H. H. Atkinson, Office Assistant, at $2 per day	18.30
J. W. Cobb, Stenographer, at $2 per day	189.50
William Easdale, Stenographer, at $2 per day	19.25
William Beall, Office Assistant, 6 days, at $2	12.00
J. R. Englebert, Draughtsman, at $5 per day	59.55
H. B. Shaw, Assistant Draughtsman, at $2.50 per day	33.56
	$11,535.71

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*Itemized detailed statements and itemized receipted vouchers covering all these amounts are to be found deposited with the State Auditor.

Amount brought forward	$11,535.71
DeB. Whitaker, Office Assistant, 10 days, at $2	20.00
Charles Baskerville, chemical work (2 years)	234.50
R. H. Mitchell, chemical work (2 years)	150.50
G. G. Stephens, Office Assistant, at $2 per day	19.25
John Whitelaw, building stone work	46.83
A. B. Kimball, Stenographer, at $2 per day	36.50
E. W. Wilson, Stenographer, at $2 per day	4.50
E. E. Brown, photographic work, at $3 per day	276.90
W. A. Smith, Office Assistant, 5 days, at $1	5.00
W. H. Rau, photographic work	74.85
T. H. Lindsey, photographic work	6.00
George B. Wills, clerical work, 60 hours, at 15c	9.00
Isaac Monroe, laborer, 1 month	20.00
George H. Williams, Geologist, at $5 per day	105.00
H. L. Harris, Assistant Geologist, one-half month	37.50
James Shaw, laborer, at $20 per month	44.00
B. Wyche, clerical work, 7.2 days, at $1	7.20
C. S. Mangum, clerical work, 24 days, at $1	24.00
A. H. McFadyen, Assistant Topographer, at $2.50 per day	127.25
H. C. Bridgers, Office Assistant, at $2 per day	8.25
J. G. Dudley, Stenographer, at $2 per day	54.00
Hilary Bynum, Janitor, 1 month	5.23
F. P. Venable, chemical work (2 years)	224.00
M. M. Smith, Clerical Assistant, 20 days, at $1	20.00
C. H. White, Clerical Assistant, at $2 per day	114.50
T. R. Foust, Topographer, 2 months, at $55	110.00
I. L. Watson, Stenographer, at $50 per month	219.25
H. Monroe, Topographer, 4 days, at $5	20.00
S. W. Tyson, laborer, 6 days, at $1.50	9.00
Charles Tyson, laborer, 6 days, at $1.50	9.00
H. E. C. Bryant, clerical work, 5 days, at $1	5.00
E. Shrier, Stenographer, 3½ days, at $2	7.00
J. B. Lewis, Topographic Assistant, 2 months	41.00
Total paid for services, 2 years	$13,630.72
Total paid for expenses, 2 years	6,364.91
Total expenses and services, 2 years	$19,995.63

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

1895-1896

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E. M. Uzzell & Co., State Printers and Binders.
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GEOLOGICAL BOARD.

GOVERNOR ELIAS CARR, *ex officio Chairman*, ...	Raleigh.
J. TURNER MOREHEAD, ...	Leaksville.
S. L. PATTERSON, ...	Yadkin Valley.

J. A. HOLMES, *State Geologist*, ...	Chapel Hill.

TABLE OF CONTENTS.

PAGE.

Letter of Transmittal 5

Report of the State Geologist 7

- Gold and Monazite 7
- Miscellaneous Minerals 9
- Clay Investigations 10
- Forest Investigations 10
- Topography and Water-powers 11
- Co-operation with United States Geological Survey 12
- Chemical Work 13
- Publications 14
- Atlanta Exposition 14
- Expenditures 15

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,
Raleigh, N. C., December 15, 1896.

To His Excellency, Governor Elias Carr,
Raleigh, N. C.

Sir:—I have the honor to submit for your consideration and approval the administrative biennial report of the State Geologist for the two years ending November 30, 1896. I beg to express my appreciation of the interest you have taken in the work of the Survey during this time.

The report contains brief descriptive statements relative to each division of our work and a summary of the expenses incurred. The vouchers and subvouchers covering each item of expenditure are filed with the Auditor.

With great respect, I have the honor to remain,

Yours obediently,

J. A. Holmes,
State Geologist.

BIENNIAL ADMINISTRATIVE REPORT OF THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1896.

By J. A. Holmes, State Geologist.

During the years 1895-'96 the Geological Survey continued its investigations of the gold, monazite and corundum deposits, and began general investigations of the clay and mica deposits. In forestry a study has been made of the middle counties and during 1896 a thorough investigation was begun of the timber trees of the State. The work of the Department of Hydrography has been greatly extended, due to co-operation with the United States Geological Survey. The topographic survey of the State has been continued in conjunction with the United States Geological Survey, and there are now a number of topographic sheets available which cover most of the mountain counties.

GOLD AND MONAZITE INVESTIGATIONS.

The investigation of the gold and monazite deposits has been in charge of Mr. H. B. C. Nitze, Assistant Geologist, who during the winter and spring months was engaged in the preparation at Washington, D. C., of the preliminary reports on the gold and monazite deposits in North Carolina. During the late spring and the early summer months he was engaged in further field work in connection with both these subjects, especially in the South mountain region, where both gold and monazite deposits occur. During the months of July and August he, in company with Mr. H. A. J. Wilkins, visited the gold fields where active mining operations were in progress throughout the entire South Appalachian region—Virginia, North Carolina, South Carolina, Georgia and Alabama, for the purpose of examining carefully the mining and metallurgical methods practiced in the several different regions. This was done with a view to preparing for publication a special report on this subject in the hope that

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as an ultimate result some better methods might be devised for the mining and metallurgical operations in the gold fields of North Carolina. A preliminary report was prepared on this subject by Messrs. Nitze and Wilkins during the month of September, and was read before the Atlanta Exposition meeting of the American Institute of Mining Engineers in October. During this latter month Mr. Nitze devoted the larger part of his time to the work of re-arranging and labelling the North Carolina geological collection at the Atlanta Exposition. His report on the monazite deposits has already been published and is now being distributed. The investigation on the gold mining and metallurgical operations is still being carried on.

During the winter months of 1896 he has been engaged in the preparation of his report on the gold mining and metallurgical methods as practiced in North Carolina and adjoining South Appalachian States. During this time he has also assisted in the revision and proof-reading of the report on the gold deposits of North Carolina, which is now nearly ready for distribution. He has also prepared the articles on gold deposits and iron deposits in North Carolina for the new edition of the Hand Book which is being published by the Department of Agriculture, and has prepared for publication several other smaller papers. During April and May and October 15th to December he has been granted leave of absence in order that he might be enabled to carry on some special investigations in connection with a new invention of a magnetic separator which it is hoped can be made useful in separating any and all of the iron-bearing minerals from monazite and non-iron-bearing minerals. During the months of July and August he was engaged in a special exploration of the iron ores, marble and other economic geologic deposits of Cherokee county.

Mr. George B. Hanna, of Charlotte, has at intervals during the year, in all about two months' time, been aiding Mr. Nitze in his investigation of the gold deposits of the State and in preparation of his last-mentioned report.

Mr. H. A. J. Wilkins has also aided Mr. Nitze during two months' time in the preparation of his report on the "Gold Mining and Metallurgical Methods for North Carolina Gold Ores."

MISCELLANEOUS MINERALS.

In the investigations relating to the non-metallic minerals, Mr. J. V. Lewis, Assistant Geologist, has devoted the winter and spring months to a careful study in the geological laboratories of the U. S. Geological Survey in Washington, D. C., of materials collected during the field season of 1894 in his study of the corundum and associated rocks in Western North Carolina. By spending the winter and spring in Washington he was not only able to use better laboratory facilities than could be supplied him by the State Survey, but he also had the advantage of constant supervision and advice from the several geologists of the Federal Survey who have been prosecuting special studies along similar lines of investigation. During the summer months Mr. Lewis was engaged in the further examination in the field of the corundum deposits and also in making a preliminary survey of the water-powers in the region west of the Blue Ridge.

The last two months of the year were devoted to the further laboratory investigations of rocks associated with corundum and in the preparation of a preliminary report on corundum and the basic magnesian rocks of Western Carolina. During the winter months of 1896 he revised his report on corundum and read the proof as it was going through the press. In February he was elected to the professorship of geology and mineralogy in Clemson College, South Carolina, and gave up his connection with the Geological Survey at the end of that month. He has proved an exceedingly useful man to the Geological Survey in many ways, and his resignation has been accepted with sincere regret on the part of all with whom he has been associated in this work. I desire to retain his connection with the Survey in such a way as to enable him to carry on at intervals investigations which he has begun, and he hopes in this way to be able to prepare in the near future the final report on corundum to be published by the Geological Survey. During his summer vacation in 1896 he spent one month in the field work in Western North Carolina.

Mr. Joseph H. Pratt, an advanced graduate student of Yale University, was engaged during the month of August and September in making special examination of the minerals associated with corundum in Western North Carolina. Mr. Pratt had spent the summer of 1892 in North Carolina as a voluntary worker in mineralogy, associated with Prof. S. L. Penfield of the Department of Mineralogy in Yale University, and was considered eminently qualified to undertake this special investigation. It is hoped that in the near future the results of his labors can be embodied in a final report on corundum and associated minerals. A large amount of mineral material was collected by Mr. Pratt during his summer investigations, which material has been carried back to New Haven and will be there examined by Mr. Pratt and Professor Penfield. During the months of July, August and September, 1896, Mr. Pratt was associated with Mr. Lewis in the investigation of the corundum deposits, and also with the State Geologist in the investigation of the mica deposits in Western North Carolina.

CLAY INVESTIGATIONS.

Dr. Heinrich Ries, during the months of May and November, 1896, was engaged in special examination of our deposits of clays, kaolins and fuller's earth. He has collected a large number of samples, and will superintend a series of tests to be made of these samples during the coming winter. During the coming year it is hoped that this investigation will have been completed and the bulletin published and ready for distribution.

FOREST INVESTIGATIONS.

The forest investigations have been carried on by Mr. W. W. Ashe and Mr. Gifford Pinchot and their results will shortly be published as a bulletin on the Timber Trees of North Carolina.

Mr. W. W. Ashe during the spring and summer months of 1895 was engaged in the further study of the forests and forest conditions of the midland counties of North Carolina, and he assisted Mr. Gifford Pinchot in the preparation of a special bulletin on the timber trees of the entire State. Mr. Ashe has also begun the preparation of a general report on the forests and forest trees of North Carolina, and another on practical forestry, or what can be done to improve and preserve the forest conditions of the State. The preparation of these reports will require considerable time and labor, as it is hoped to make them of considerable value to the people of the State. During the winter and spring months of 1896 Mr. Ashe continued his investigations into the forests and forest conditions of the middle counties. During the month of May he has traversed a number of these counties with a buckboard and has collected a considerable amount of additional material to be used in the prosecution of his studies of the forest trees and the forest flora of the State. During three months, June to September, of the summer, Mr. Ashe suffered greatly from a prolonged attack of typhoid fever, and his field work was in this way greatly interrupted. During the last three months of the year he has continued his studies of the hard wood forests of middle North Carolina, and is superintending the publication of the report on timber trees. He has also continued to collect material for the preparation of an elaborate report on the forest trees and forest flora of the State, which he hopes to have ready for publication in the near future.

Mr. Gifford Pinchot during the first six months of this year devoted a considerable portion of his time, without remuneration, to the preparation of the report on the timber trees of North Carolina, referred to above, and is now aiding in the supervision of its publication.

TOPOGRAPHY AND WATER-POWERS.

In topography a considerable amount of work has been done during the seasons of 1895 and 1896 in the way of revising the atlas sheets covering the southwestern counties of the State, especially the Cowee sheet, which embraces Jackson and portions of adjacent counties. A majority of the atlas sheets covering the region west of the Blue Ridge have already been revised, and we will soon have excellent topographic maps of that entire region. The topographic surveys have now covered one-third of the total area of the State.

Hydrography.—Another important work undertaken by the State and Federal Surveys jointly during the summer of 1895 is that of measuring the water supply of the more important rivers of the State, in connection with the investigation of water-powers, and this work has been continued through 1896. One great drawback to the development of our water-powers in North Carolina and other Southern States is the fact that we have no authentic data to indicate the amount of water which can be depended upon in these rivers throughout the year, especially in very dry seasons. The object of this work is to measure the water supply in the more important of our rivers every day in the year, and at intervals during the year, especially during times of low water and high water in the rivers. It is the purpose of the Survey to have special measurements made of the velocity of the water at certain points in the more important rivers, in order that we may be able to determine the amount of water flowing along the stream, and consequently the horse-power per foot of fall that can be depended upon. Five stations on the Roanoke, the Cape Fear, the Yadkin, the Catawba. and French Broad rivers respectively have been established for the making of these measurements, and it is expected that in the near future a number of additional stations will be established and that the work will be considerably enlarged.

During the summer and autumn of 1895, Mr. C. C. Babb, a hydroprapher connected with the U. S. Geological Survey, was engaged in this work on the part of the U. S. Geological Survey. He was assisted during this time by Messrs. J. V. Lewis and E. W. Myers of the State Survey.

Mr. E. W. Myers has during 1896 been engaged in the measuring of the water-powers on various rivers of the State, and is now aiding in the preparation of his report. Under his immediate supervision have been seventeen special assistants (paid by the U. S. Geological Survey), who have been making detailed daily measurements as to the height of the water on each of our more important rivers. His salary is paid jointly by the Federal Survey and the North Carolina Geological Survey. It is hoped that during the present year a considerable increase can be made in the number of rivers upon which stations are located and that there can also be an increase in the number of stations on the more important rivers in this State, such as the Yadkin and the Catawba.

CO-OPERATION WITH THE U. S. GEOLOGICAL SURVEY.

The U. S. Geological Survey has during the past two years cooperated with the State Survey along four different lines of work as follows:

(1) In Geology, Mr. Arthur Keith, has spent his summers in examining the geologic formations in portions of Mitchell, Watauga and Caldwell counties, this work being under the general supervision of Prof. C. R. Van Hise also of the U. S. Geological Survey.

Prof. Van Hise, Mr. Keith and the State Geologist made during March, 1896, a reconnoissance trip across the entire mountain region at two different points, one along the Hiawassee river and the other across from Johnson City, Tenn., to Lenoir, N. C. Prof. Van Hise spent September of the same year in other counties of the mountain region along the western borders of the State.

(2) In the making of the topographic maps there have been two U. S. Geological Survey parties in the field, one making a general map of portions of Transylvania, Haywood and Buncombe counties, the other party making a special map of the Pisgah mountain region. The first of these parties was in charge of Mr. Cummin during the earlier part of the summer season, and later, with Mr. Wheat. The other party of the Pisgah region was in charge of Mr. W. L. Miller.

(3) In running a line of exact levels across the State, the U. S. Survey has co-operated with the State Survey to the extent of furnishing one Chief Leveller, Mr. H. C. Hall, and the State furnishing his three assistants, viz.: Messrs. Durham, Ford and Faison. The latter recently resigned and was replaced by Mr. Horton. This work was begun on November 1, 1896, and will be continued during the winter.

(4) In the investigation of the rivers and water-powers of the State, the U. S. Geological Survey pays the salaries of all the river observers who make daily gauges as to the height of the water in the principal rivers, and also co-operates in paying the expenses and salary of Mr. E. W. Myers, who has the special supervision of these men in hand.

CHEMICAL WORK.

Dr. F. P. Venable has continued during the past two years to superintend the chemical work of the Survey, the larger part of which has been done by the Assistant Chemist, Dr. Charles Baskerville. In addition to this, Dr. Venable has made a number of special analyses of the mineral waters of the State, and has in preparation a bulletin on this subject. Dr. Baskerville's time has been mainly occupied in making assays of gold, silver and iron ores, and analyses of clays and building stones. He has also made a number of miscellaneous analyses of rocks and minerals.

Mr. R. H. Sykes has during the year acted as Stenographer and Clerk for the Survey, devoting about half his time to this work.

PUBLICATIONS.

The results of those investigations of the Survey that have been completed have been published in the form of bulletins as follows:

Bulletin 3, Gold Deposits in North Carolina, by Henry B. C. Nitze and George B. Hanna; 196 pages and 14 plates.

Bulletin 9, Monazite and Monazite Deposits in North Carolina, by Henry B. C. Nitze; 47 pages and 5 plates.

Bulletin 11, Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. Volney Lewis; 107 pages and 6 plates.

STATE GEOLOGIST—ATLANTA EXPOSITION.

The State Geologist has, as nearly as possible, given personal supervision to all of this work which has been done in the State. In addition to this he has conducted the correspondence of the Survey, which continues to grow in magnitude. He has supervised the publication of Bulletins Nos. 3, 9 and 11, and revised the manuscript of two forestry bulletins. He has aided in the preparation of several additional bulletins to be published shortly. In addition to this he has continued his explorations of the coastal plain region in the eastern counties, where he has made a number of examinations relative, especially, to the water supply of the eastern counties, and has made some preliminary examinations of the gold deposits of the State. During the late summer and early autumn, from July to September, 1895, inclusive, a considerable part of his time was given up to making collections and other preparations for a North Carolina exhibit at Atlanta Exposition, and from September 1st to the end of the fiscal year a considerable portion of the time was necessarily given to the arrangement and maintenance of this exhibit at the Exposition.

This effort on the part of the Geological Survey to make an exhibit at the exposition, which would represent the mineral wealth of the State, has, during the latter half of the year, interfered considerably with the regular work of the Survey, and has entailed some expenses which have necessarily curtailed the expenses of the Survey in other directions. The making of this exhibit would not have been undertaken by the Survey but for the understanding that the Exposition authorities were to bear the necessary expenses in so large a measure that very little was to be required of the State Survey in the expenditure of either time or money, other than the arrangement and shipment of the exhibit to the Exposition. It was found, however, soon after the exhibit reached Atlanta that the Exposition Company was unable to meet the demands made upon them in this direction, and it became necessary at that time for the State Survey either to withdraw from the endeavor to make a North Carolina exhibit or to devote a considerable amount of its own funds and of the time of its officers to the work in order to make it a success. It was too late to withdraw, and we accepted the other alternative and have done the best we could with the limited funds at our disposal towards making an exhibit which would be at least not a discredit to the State. However, the efforts of the Survey in that work have been successful, and both the North Carolina Mining and Forestry exhibits have won general praise from the public and have been awarded gold medals by the Exposition Judges.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and subvouchers. These are grouped together and deposited with the Governor, as nearly as practicable, at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such examination and approval the vouchers and itemized statements of expenditures are deposited with the State Auditor, where they are open to public inspection. The State Geologist gives bond in the sum of twenty-five hundred dollars; and at no time can the funds at his disposal for meeting such expenditures exceed this amount.

The accompanying statements show the expenditures of the Geological Survey for the two years ending November 30, 1906, grouped according to the subjects investigated during this time, the purposes for which funds are allotted, and the persons receiving compensation from the Survey.

EXPENDITURES OF THE NORTH CAROLINA GEOLOGICAL SURVEY FOR THE TWO YEARS ENDING NOVEMBER 30, 1896, GROUPED ACCORDING TO THE SUBJECTS INVESTIGATED:*

Gold and monazite investigations	$ 3,235.70
Corundum and mica investigations	2,377.40
Forestry investigations	2,189.52
Water-powers and topography	1,301.67
Water supply, clay and general explorations	1,532.27
Chemical work and materials	1,615.67
Photographs and illustrations	115.95
Equipment and repairs	911.65
Freight and express	153.87
Postage and telegrams	167.17
Books	130.14
Expenses of Geological Board meetings	155.05
Salary of State Geologist	5,000.00
Clerical assistance	829.17
Office supplies	271.95
Total	$19,987.18

AMOUNTS PAID FOR SERVICES TO THE SEVERAL PERSONS CONNECTED WITH THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1896:*

J. A. Holmes, State Geologist, 2 years	$5,000.00
H. B. C. Nitze, Assistant Geologist, 13 months, at $180	2,340.00
J. V. Lewis, Assistant Geologist, at $85 per month	1,332.80
W. W. Ashe, Forester, 19 1-2 months, at $80	1,657.50
Charles Baskerville, chemical work, 2 years	1,093.49
E. W. Myers, Water-powers Engineer, 6.13 months, at $50	307.50
S. F. Telfair, Secretary, Geological Board, 4 days, at $3	12.00
T. R. Foust, Topographer, 10 days, at $2	20.00
John A. Ramsey, Engineer, 28 days, at $5	140.00
W. C. Riddick, Engineer, 5 days, at $5	25.00
T. S. Burkhead, Stenographer, 4 1-4 days, at $2	8.50
N. L. Shaw, Janitor, at $7 per month	125.00
James Higgs, Assistant in Office, 10 days	10.00
F. P. Venable, chemical work	27.60
Charles E. Cook, Topographer, at $5 per day	695.91
Rachel Blythe, 5 1-2 days, at $2	11.00
George B. Hanna, Special Assistant in Gold Investigations, at $5 per day	232.00
T. L. Wright, Office Assistant, at $2 per day	54.30
	$13,092.60

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*Itemized detailed statements and itemized receipted vouchers covering all these amounts are to be found deposited with the State Auditor.

Brought forward	$13,092.60
I. L. Watson, Stenographer, one-half month, at $50	25.00
R. B. Taylor, carpenter work	26.58
D. L. Nicholson, Office Assistant, 1 month	20.50
A. B. Kimball, Office Assistant, at $2 per day	40.25
E. J. Wood, Office Assistant	6.10
S. A. Smith, Office Assistant, 234 hours, at 10c	23.40
William Davis, laborer, at $1 per day	20.92
T. C. Harris, Clerk, 5 days, at $1	5.00
R. H. Sykes, clerical work, 12 months	307.50
John W. Radcliffe, laborer, at $1 per day	10.50
J. H. Pratt, Assistant Geologist, 5 months, at $50	250.00
W. S. Sweat, laborer, at $1 per day	19.00
W. J. Yaste, laborer, at $1 per day	11.50
John Gonella, laborer, at $1 per day	18.40
William Rackle, laborer, at $1 per day	35.00
DeMallie & Allen, laborers, at $1 per day	5.00
George W. Oliver, laborer, at $1 per day	33.10
DeL. W. Gill, Draughtsman, 6 days, at $3	18.00
R. M. Eames, gold expert, 3 days, at $2.50	7.50
F. P. Venable, chemical work	297.00
Miss R. Pickard, Stenographer, 15 days, at $1	15.00
A .T. Allen, Clerical Assistant, 12 days	12.00
W. N. Walton, laborer, 5 days, at $1	5.00
H. A. J. Wilkins, Expert in Gold Investigations, 2 months, at $100	200.00
A. Henderson, Topographer, 1 month	60.00
G. N. Coffey, Office Assistant, 55 hours, at 12 1-2c	6.88
J. W. Cates, carpenter work	5.75
H. Meredith, carpenter work	2.15
H. Pheribo, laborer, 1 month	20.00
Total paid for services, 2 years	$14,653.63
Total paid for traveling and office expenses, equipment, etc	5,333.55
Total of all expenditures, 2 years	$19,987.18

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

1897-1898

RALEIGH:
E. M. UZZELL & CO., STATE PRINTERS AND BINDERS.
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GOVERNOR D. L. RUSSELL, *ex officio Chairman*,	Raleigh.
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CHARLES MCNAMEE,	Asheville.

J. A. HOLMES, *State Geologist*,	Chapel Hill.

TABLE OF CONTENTS.

PAGE.

Letter of Transmittal 5

Report of the State Geologist 7

- Clay Deposits and Clay Industries 7
- Gold Investigations 8
- General Mineral Investigations 9
- Water-power Investigations 11
- Electric Transmission of Power 13
- Forestry Investigation 14
- Geologic Work in the Western Counties 17
- Topographic Work 17
- Mineral Waters 19
- Drinking-water Supplies 20
- Artesian Water Supply 21
- Drainage of Lands in Eastern Counties 22
- Magnetic Survey 23
- Road-building Materials 24
- Chemical Work 25
- Office Work 25
- Publications 25
- Expenditures 26

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,
Raleigh, N. C., December 15, 1898.

To His Excellency, Governor D. L. Russell,
Raleigh, N. C.

Sir:—I have the honor to submit for your approval the administrative biennial report of the State Geologist for the two years ending November 30, 1898. The report includes brief statements of the operations and expenditures of the Survey during this period.

The scientific and economic results of these investigations are given in special reports of which several have already been published and others are now being prepared for the printer. Vouchers covering the receipted itemized accounts of expenditures have been approved by the Geological Board and filed with the State Auditor.

I beg to express my appreciation of the continued and cordial interest and spirit of helpfulness you have shown in the work of the Survey throughout your entire administration.

With great respect, I have the honor to remain,

Yours truly,

J. A. Holmes,
State Geologist.

BIENNIAL REPORT OF THE STATE GEOLOGIST ON THE OPERATIONS OF THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1898.

By J. A. Holmes, State Geologist.

The work of the Geological Survey during the past two years has been continued along the same general lines as were pursued during the two previous years, but in the course of the work some new subjects have been taken up, as will appear in the statements submitted below. The work has been mainly in connection with the investigation of the following subjects:

1. The Clay Deposits and Industries.
2. Gold Deposits and Mining Methods.
3. General Mineral Resources, such as Mica, Corundum, Talc, Marble and Miscellaneous Mineral Deposits.
4. Water-powers.
5. Forests and Forest Resources.
6. General and Economic Geology of the Western Counties.
7. Topographic Maps.
8. Mineral Waters.
9. Drinking Water Supplies, and Especially Artesian Water Supplies for the Eastern Counties.
10. Irrigation and Drainage of Swamp Lands.
11. A Magnetic Survey of the State.
12. Road-building and Road Materials.

CLAY DEPOSITS AND CLAY INDUSTRIES.

The investigation of this subject was undertaken jointly by the State Geologist and Dr. Heinrich Ries of the Columbia School of Mines, New York, in 1896, and the work for the preliminary report, which is now in the hands of the printers, was finished in July of the present year. Clay deposits were examined in some seventy different localities; and the clay industries, including the manufacture of

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brick of different grades, the manufacture of drain tile and sewer pipe, terra-cotta flues, and general pottery ware, were examined in all regions of the State where they were known to exist. The analyses of these clays have been made in the chemical laboratory of the State University by Dr. Charles Baskerville. The various physical tests, including plasticity, fusibility and proper admixture of these clays have been made in the laboratory of the School of Mines, Columbia College, New York.

In connection with this investigation it was found that all of the fancy brick, and even many ordinary brick, much of the sewer pipe, all of the china ware and a large part of the better grades of pottery ware used in North Carolina are imported from other States; but these investigations have shown that the clay deposits of North Carolina are of such quality and quantity that all of these different articles may be manufactured in the State. Indeed the kaolin which is shipped from Jackson county, in North Carolina, is not only equal to any other in color and other general qualities, but is superior to that shipped from Florida, inasmuch as it shrinks less, consequently our Jackson county kaolin is being used in the manufacture of the finest chinaware now made at Trenton, Baltimore and at East Liverpool, Ohio.

The report on this subject which is now in the press describes not only our clay deposits and the present condition of our clay industries, but also describes the better and more modern method of manufacture of different clay products. There is already a considerable demand for it in advance of its publication, and it is believed that it will render an important service to the State in the way of improving and enlarging our clay industries.

GOLD INVESTIGATIONS.

The report on the Gold Deposits of North Carolina, which was prepared jointly by Mr. H. B. C. Nitze of this survey, and Mr. George B. Hanna of the U. S. Assay Office in Charlotte, was printed a year ago, and in response to a considerable demand for such information it has had a wide distribution. Already it has been instrumental in bringing several hundreds of thousands of dollars of capital into the State for the development of gold mining properties and its usefulness in this direction has only fairly begun.

The investigations in this field of work during the latter part of 1896 and the earlier half of the present year were carried on mainly by Mr. Nitze, and the result of those investigations has been the preparation of a report on the most approved gold mining and metallurgical methods which are being used at the present time in North Carolina and other Southern States; but investigations in this case were extended into other States in the hope that some methods for mining and treatment of ores might be found in operation there which would be useful in helping to solve the difficulties met with in North Carolina.

The most important condition necessary for the development of the North Carolina mines at the present time is the establishment at one or more points in the State of such metallurgical plants as will successfully and cheaply treat the low grade sulphuret ores, which may be said to range in value from $3 to $10 per ton. As one of the means of securing the establishment of such plants, the Geological Survey is endeavoring to demonstrate the fact that we have at accessible points sufficient quantities of these low grade ores for the operation of smelters or other metallurgical plants, so that they can feel assured of securing sufficient quantities of ore for continuous work.

One of the difficulties met with in connection with the supply of such ores is the fact that many of the workable mines are located at a considerable distance from the railroad, and the country roads connecting them with the railroads are in such miserably poor condition that hauling with wagons is far too expensive. The report on the Gold Mining and Metallurgical Methods is in the hands of the printers and will be ready for distribution in a few weeks.

GENERAL MINERAL INVESTIGATIONS.

The more common and important minerals in the State, such as the iron, gold and silver ores, mica, corundum, monazite, kaolin and the clays have been considered worthy of special investigation, and special reports have either been published already or are in preparation concerning each of these; but there occur in North Carolina large numbers of miscellaneous minerals, some 185 or more in all, a number of which are exceedingly rare and of great scientific interest, while a number of others have added economic value. Thus the gem-producing minerals, mainly beryl, garnets, corundum (rubies and sapphires), emerald and topaz, which are being mined in our mountain counties, yield annually from twenty to thirty thousand dollars worth of gems; and it is believed that as one of the results of our investigations this industry will be largely increased during the next year.

In every county in Middle and Western North Carolina there are many deposits of miscellaneous minerals which have never been carefully examined and, hence, it has been thought best to make a detailed investigation of these deposits, beginning with the extreme western counties and working eastward, indicating the position of these various mineral deposits on the topographic maps, and also preparing the descriptions of them for publication in the reports. The details of this work have been entrusted to Dr. Joseph H. Pratt, a graduate of and for sometime an instructor in Yale University. Dr. Pratt has already spent portions of several years in North Carolina, and during a part of this time has been in the employ of the Survey, but it is thought best that during the coming year he should devote his entire attention to this work, so as to carry it forward more rapidly.

The work has been organized along three lines: (1) The identification of specimens sent to the Survey office by persons in different portions of the State and the reporting of the results of such examinations to such persons; (2) the personal examination in the field of the various mineral deposits that could be found; (3) the preparation of the results of these examinations, for publication both in the scientific journals of the country and in the reports of the Survey.

In connection with this branch of the work the State Geologist has devoted a considerable portion of his time to the investigation of *mica deposits* in Western North Carolina, and incidentally he has examined the mica deposits in a number of other States with a view of determining there the possibilities of competition with the North Carolina mica, and with a view also of determining the most economic methods for mica mining which might be introduced in the North Carolina work. This State continues to produce the largest portion and the best quality of mica mined in the United States.

The corundum deposits have been investigated at intervals during the past two years by Dr. Joseph H. Pratt, the Mineralogist of the Survey, and in the laboratory work he has been assisted by Mr. J. V.

Lewis, who was formerly connected with this Survey, but is now Professor of Geology in the Clemson Agricultural College, South Carolina. North Carolina still produces much the larger part of the corundum mined in the United States; the principal mines being located in Jackson and Macon counties. Lesser deposits of corundum are known to occur in several of our mountain counties, and east of the Blue Ridge, especially in Iredell county. It is expected that the final report on the corundum deposits will be completed by Messrs. Pratt and Lewis sometime during the next year.

Our miscellaneous mineral deposits in the western counties have been investigated during the past two years by Dr. Pratt, and these investigations will be continued during 1899. Beginning in the mountain counties, he will gradually work eastward, so that in the future he will be able to prepare for publication a report on the miscellaneous mineral deposits of the entire State.

During the past two years Dr. Pratt has prepared a number of valuable papers on subjects relating to the minerals of North Carolina, and has others now in preparation.

WATER-POWER INVESTIGATIONS.

In the engineering division of the Survey during the past year work has been carried on as follows:

Stations have been established and measurements have been made of the flow in the Roanoke river at the crossing of the Norfolk & Carolina Railroad near Neals; on the Tar river at Tarboro; on the Neuse river near Selma; on the Cape Fear river at Fayetteville; on the Yadkin river near Salisbury and near Norwood; on the Catawba river at Catawba Station, and near Rock Hill, South Carolina; on the French Broad river at Asheville; on the Tuckaseegee river at Bryson City; on the Little Tennessee river at Judson, and on the Hiwassee river at Murphy. During May, 1898, stations were also established on the Deep and Haw near Moncure.

At all these stations daily observations of the stage of the river are made and recorded, and at intervals during the year the stations are visited by our engineer and an instrumental gauging of the volume of the water is made.

The services of the observers are paid for out of an appropriation provided for this purpose out of the funds of the United States Geological Survey, and a considerable portion of the expenses of the engineer are also paid out of funds from the same source.

The expense of maintaining these stations is such that only a limited number of them could be established. In locating these stations we have endeavored to select places as near as possible to the regions where water-power development might be reasonably expected, and which would be easily accessible both for daily measurements and for the occasional examinations for the measurements of the flow by the engineer. Owing to the importance of the Yadkin and the Catawba rivers, two stations have been established on each of these streams; the one just above and the other just below the region of greatest water-power possibilities.

These measurements have primarily as their object the accurate determination of the flow of the streams at all stages of water, in order that information may be furnished investors who are seeking water-power. Accurate knowledge of this sort is of the greatest importance in connection with the development of water-powers; and owing to the absence of such data concerning many streams, the development of many good powers has been retarded.

In various parts of the State water-powers have been visited, the fall measured and the locality described for publication in the bulletin on the water-powers in North Carolina now being printed. Quite an extended reconnoissance trip was taken during the summer and autumn of 1895 through the counties west of the Blue Ridge by Messrs. E. W. Myers and J. V. Lewis, who visited all the important streams, locating the shoals thereon. Since that time, and especially during the year 1898, the work has been carefully revised.

There is a prevailing opinion in manufacturing circles that the volume of water in the South Atlantic rivers varies so greatly that in the dry seasons of the year the power available from this source becomes inadequate for large manufacturing purposes. The results of the measurements at the stations mentioned above have thus far been quite satisfactory in demonstrating the fact that even in the dry seasons of the summer our larger rivers have a water supply sufficient to develop ample power for manufacturing purposes. When these investigations have been carried on a few years longer, so as to include beyond any question the dryest possible seasons, the records will be sufficiently complete to furnish such information as may be demanded by the most cautious investors along this line.

The Survey has already, through the results of this work, been able to give much information to parties interested in water-power development, and, as the work is extended, its usefulness will largely increase, and result in bringing to the attention of investors and manufacturers the possibilities of development in this direction.

It is the purpose of the Survey, during the year just beginning, to continue the work of locating the available water-powers in the midland and mountain counties, and to run lines of levels up the principal streams, measuring accurately the fall and noting briefly facilities for development.

These inquiries concerning our water-powers have increased more and more each year, and this is especially true since the transmission of power by electricity from inaccessible points on rivers to existing manufacturing centers or lines of railway has been demonstrated not only to be possible, but feasible.

From time to time during the past two years the Geological Survey has published information concerning our larger water-powers in a number of papers, and in this way had distributed widely information concerning them. Already, since this work relating to the water-powers was begun, more than two million dollars have been invested in the development of these water-powers.

Through the co-operation of the United States Weather Bureau, additional rain-fall stations will be established in several selected localities, in order that the distribution of the rain-fall may be more accurately known and its relation to the flow of the streams more definitely determined.

These river and water-power examinations have been largely made by Mr. E. W. Myers, engineer of the Survey.

ELECTRIC TRANSMISSION OF POWER.

The most noteworthy water-power development in the State during the past year has been that on the Yadkin river near Winston by the Fries Power Manufacturing Company. From this point the power is transmitted as electricity, 13 miles to Winston and Salem, when it is distributed and used in the running of a number of manufacturing enterprises. This is the first time in North Carolina that water-power has been developed and transmitted electricity to the factories. In the near future there will be large developments along this line. During November I visited several places in the Western States where power was transmitted electrically for distances varying from 20 to 40 miles; and in Southern California I found a plant nearly completed, where it was intended to transmit power in this way for a distance of 80 miles, from Santa Anna Canon to Los Angeles. It is estimated that the loss of power in this transmission will be less than 10 per cent. The development of water-powers in North Carolina has been heretofore greatly retarded by the fact that they were located usually at considerable distances from railway transportation, but there is now no reason why these should not be developed, and the power transmitted electrically to the manufacturing centers, where it can be distributed to the smallest as well as the largest establishments; and I see no reason why towns, as well as corporations, should not make use of power developed and transmitted in this way for the running of electric lights and electric car lines; and it is possible that in the near future we may witness power transmitted electrically from the Roanoke at Weldon to Raleigh for operating manufacturing enterprises; from the Yadkin to Lexington, Salisbury and Concord; and from the Catawba to Charlotte, Statesville and Hickory.

The work now in progress in the Yadkin river, which is the making of a topographic map of that part of the Yadkin river from below the Narrows to a point some 20 miles above, in which distance are located its most important water-powers, will be completed early in 1899, and the results published in the bulletin on the water-powers of the State.

FORESTRY INVESTIGATION.

These investigations during the past few years have consisted largely in an examination and description of the timber supplies and general forest conditions of the State, and have been carried on largely by Mr. W. W. Ashe of the Survey. The object of the work has been twofold; (1) To show to investors elsewhere what exists in North Carolina in the way of valuable timber resources; (2) to educate our own people to a realization of the value of their forest lands and how these might be perpetuated for the future, while also yielding a valuable income for the present. A considerable amount of attention has been devoted to the subject of forest fires, and we have endeavored to arouse public sentiment to a realization of the terrible destructiveness of these fires and to the importance of and methods for preventing them. It has been the policy of the Survey in this work that, while advertising and aiding the legitimate development of our timber resources, we have by the publication of our reports and by frequent contributions to the press of the State, endeavored to call the attention of our people to the reckless and unnecessary destruction of our forests.

I am glad to be able to report that we are now beginning to see some results from this work of education, and even some of our largest lumbermen of the State are beginning to realize the danger of continuing the present destructive methods, and are joining together to put a stop to forest fires and to the careless cutting of timber, and thereby the destruction of the younger growth. In addition to the destruction through forest fires they are coming to realize the very large amount of damage done to our forests by the running at large of cattle and hogs, especially in the pine region of the eastern counties.

Another result of this educational campaign has been the recent organization of the North Carolina Forestry Association, which will in the future aid in bringing about better forest management for which the Survey has been laboring. Mr. Ashe has already published a report on the forests and forest conditions of the eastern counties, and a similar one on forest fires. Together with Mr. Gifford Pinchot, he has also prepared for publication by the Survey a report on the timber trees and forest conditions in North Carolina which has been praised by the forestry journals of the country as one of the most valuable recent contributions to forestry literature. There has also been published the first of a series of economic papers relating to the maple sugar industry of the State.

We have clearly recognized the fact that the greatest opportunities for work in practical forestry exist in the eastern counties, and that the great timber tree in that region, now and for the future, is what is popularly known as the loblolly or short-leaf pine. The cypress and juniper timber of that region has already been largely cut; the hard woods are of less importance there than in the western counties; and the long-leaf pine, though once common and valuable as far north as Virginia, is now rapidly disappearing and is being replaced by the more rapidly growing and easily protected loblolly pine even along the Cape Fear. During the summer and autumn of 1898, through the co-operation of the United States Department of Agriculture, the Geological Survey has been able to undertake a detailed study of the growth of this loblolly pine in our eastern counties. The principal points to be determined in this investigation are the rate of growth and the acre yield of the loblolly pine on different kinds of soil; and especially on those soils which, on account of their inadaptability to agricultural uses, should be kept covered with valuable forest growth. We are endeavoring to determine the best methods of managing forests of this tree, both on a large and small scale, and how the largest yield of timber can be obtained in the shortest period of time, and with the greatest profit. It is hoped, as the principal result of this examination, that the owners of large forest areas in Eastern North Carolina may be induced to manage their forest lands in such a way that they may not only cut the mature timber of to-day, but may also protect the younger trees in such a way as to perpetuate these forests for future use. These investigations are being carried on jointly by Mr. A. K. Mlodziansky of the Forestry Division of the United States Department of Agriculture and Mr. W. W. Ashe of the Geological Survey. For this co-operation we are indebted to Mr. Gifford Pinchot, who has already done so much for North Carolina in the way of practical forestry.

Mr. Ashe is also continuing an investigation of the swamp lands of the State, begun a few years ago. The object of this investigation is to determine the most practical method for developing a valuable forest growth on that portion of these areas which is not suitable for agricultural purposes, and incidentally, we are studying the soils of these swamp areas in order to determine the extent to which portions of them may be adapted to agricultural purposes, and other portions to valuable forest growth.

Sets of specimens, in the State Museum, representing in part the medicinal plants of the State, were also provisionally arranged so as to be accessible for reference. Most of this material was also labeled and a preparatory study was begun for the work on the medicinal and other useful forest herbs of North Carolina as among the forest by-products. The importance of this work will be more readily realized when we bear in mind the fact that the sale of these herbs brings into the State yearly more than $300,000..

GEOLOGICAL WORK IN THE WESTERN COUNTIES.

As representing a part of the work of the United States Geological Survey in North Carolina, co-operating with the State Survey, Mr. Arthur Keith, one of the geologists of the United States Geological Survey, has been for the past several years assigned to work in North Carolina in the western counties, these being the only counties of which accurate topographic maps are in existenc. During the past two years Mr. Keith has been doing work in structural and economic geology in Watauga, Burke, Caldwell, Mitchell, McDowell, Yancey, Buncombe, Cherokee, Macon, Graham and Clay counties. In McDowell, Yancey and Buncombe counties new areas were surveyed by him, while in the other counties mentioned, the work which was begun during the past few years was continued, additional facts having been discovered.

Mr. Keith has examined especially the iron ore deposits in Mitchell and McDowell counties; the marble deposits in McDowell and Cherokee; the talc deposits in Swain, Macon and Cherokee, and other lesser mineral deposits in the several counties. He has now in preparation a report on the structural and economic geology of the Cherokee region, and another on the geology of the Cranberry region. Mr. Keith and Prof. Van Hise, also of the United States Geological Survey, have devoted some time to a study of the age and character of the geological formations in the region of the Great Smoky Mountains.

TOPOGRAPHIC WORK.

Considerable progress has been made during the year in connection with the great topographic and economic map of the State, which is being prepared jointly by the United States Geological Survey and the State Survey. In connection with the making of this topographic and geologic map, it was found that east of Salisbury no exact lines had ever been surveyed and no elevations had ever been determined accurately; consequently it was deemed necessary in connection with this work to run a carefully surveyed line of levels from the ocean at Morehead City across the State. In order to lessen the expense of this work the co-operation of the United States Geological Survey and the Atlantic & North Carolina and the Southern Railways was obtained; the United States Geological Survey agreeing to furnish one expert leveler and all of the expensive instruments necessary; the railroad companies agreeing to furnish free transportation for all the members of the party, a car in which the party could live, and to move this car from station to station along the railroad line as it might be necessary; and in addition the Atlantic & North Carolina Railway furnished two men to serve as chain-carriers; the State Survey furnishing the two rodmen, one traverse man and a cook, and provisions for the entire party. Along the line of the Southern Railway the State Survey also furnished two chain-carriers.

The surveying of this line was begun at Morehead City after having carefully determined the elevation at that place above the mean tide of the ocean; and during November and the five months following, the line of exact levels and traverse line were extended along the Atlantic & North Carolina Railway from Morehead City to Goldsboro, and along the line of the Southern Railway from Goldsboro to the Tennessee line at Paint Rock.

The running of this line of exact levels will be of great service not only in the making of the economic map of the State, but also in determining the exact elevation of all points in North Carolina by using this line as a basis. The elevation of various other points in the State can be determined from the railroads crossing this line. The leveling (which was done by Mr. W. Carvel Hall of the United States Geological Survey) was carried on with so much accuracy that in the total distance of 457 miles from Morehead City to Paint Rock the probable error was not greater than 275 thousandths of a foot.

In the line of the regular topographic work, the Survey of what is known as the Pisgah sheet, which includes portions of Buncombe, Henderson, Transylvania, Haywood and Jackson counties, was completed during the present year, and the map covering that region will be prepared for engraving during the present winter. The United States Geological Survey also completed during this year that part of the Cranberry atlas sheet which lies in Mitchell and Caldwell counties.

In a portion of the Pisgah area, on account of the important forestry investigations being carried on there by the Biltmore estate, it was deemed advisable to have the map of that region on a somewhat larger scale and made more accurately. Consequently the map of that region of approximately 210 square miles (134,000 acres) is made on a scale of 1-45000, or approximately one and a third inches to the mile and with a contour interval of fifty feet.

As illustrating the care with which this sort of work must be done in order that it may have a permanent value, it may be stated that in making the survey more than 300 (three hundred) separate stations were located by careful trigonometrical methods; the exact elevation of 232 points was determined by means of the engineer's level and connecting lines with the railroad at Asheville. Twelve permanent bench marks were erected, upon the brass top of which the elevation of each of these points was stamped; and there were run 335 miles of traverse lines, chiefly on foot, with a stadia.

The total cost of this special map was $3,850, or $18.26 per square mile; the relatively high cost of the work being due to the extreme ruggedness of the country, the fact that a larger part of the surface was covered with forest growth, and the great amount of detail necessary in order to insure the accuracy of the work.

Of the total cost of the field work in the preparation of this map, the United States Geological Survey contributed $2,335 and the Biltmore estate contributed $1,500. The only part that the State Survey took in the work was to organize it and push it through to completion.

MINERAL WATERS.

From time to time the Survey has received numerous inquiries concerning the mineral springs of the State, and numerous applications from parties in different counties of the State that examinations be made of supposed mineral waters on their lands. In endeavoring to answer both these demands as nearly as possible inquiries were instituted in all of the counties of the State concerning the existence of mineral springs which had anything more than a local reputation and which appeared to possess really mineral constituents which could be claimed to have medicinal properties. As a result of these preliminary inquiries during the past two years some eighty different mineral springs, occurring in about one-half of the counties of the State, have been examined as to the supply and temperature of the water; and samples, consisting of from three to ten gallons, in different cases, of the water from these springs have been collected and analyzed by Prof. F. P. Venable of the State University, with a view of determining their mineral constituents and properties. More than one hundred samples of these mineral waters have already been analyzed. Observations have also been made as to the temperature and volume of water at the different springs. The results of these observations will be published in a report that will appear at an early date.

DRINKING WATER SUPPLIES.

Another subject, the investigation of which was begun some two years ago, is that of the general drinking water supplies in the different portions of the State. In the western counties the supply of most excellent drinking water is ample for all purposes, and the waters are as pure as could be desired, except where they are contaminated from the careless location of pig-pens, barn-yards, privies, etc. In the middle counties the problem of suitable water supplies, especially for the larger towns, is one which presents difficulties in many cases. The streams are more or less sluggish, generally muddy, and often located at a distance from the town so great as to make the pumping of water to the town too expensive. Consequently we have received numerous inquiries from these town authorities as to the feasibility of water supplies from deep wells. In the past this has been generally regarded as an impracticable undertaking on account of the numerous failures to obtain waters from such wells in regions where the hard crystalline rocks exist; but during the past year the conditions prevailing in this region have been studied more carefully, and several such wells have been bored, especially in adjoining States, with pronounced success, and the boring of these wells has given considerable encouragement and new interest to the subject in all midland counties.

But it is to the possibility of artesian water supplies in our eastern counties that the Survey has given the larger part of its attention in this direction. The reputation of Eastern North Carolina has suffered so seriously from the prevalence of malaria in many regions that its development has been seriously retarded in the past, and many who would otherwise have settled in that region and would have helped to build it up have been kept away by the fear of malaria. During recent years, however, it has been shown by unmistakable and abundant evidence that at least much of the sickness prevalent in this region was due to the contaminated drinking water from surface springs and shallow wells in which abound organic matter such as favors the development of disease.

ARTESIAN WATER SUPPLY.

The substitution of cistern water in these eastern counties for drinking purposes is practicable only among the most intelligent class of people, for the reason that the cisterns require a considerable amount of careful and intelligent supervision in order to prevent their becoming even more serious sources of disease than the surface springs. In view of these facts the Survey has undertaken the examination of the geological formations of the eastern counties with a view of determining the possibility and feasibility of artesian water supplies in different portions of this region. Some years ago it was claimed even by geologists that artesian water supplies were not possible in Eastern North Carolina; but the present Geological Survey has taken a different view of the matter and advised the boring of an artesian well at Wilmington several years ago. The flow of water was successful from a depth of 500 feet, but the water was salty in character, and owing to some accidents to the machinery the project was abandoned for the time. It has recently been taken up again, however, and the Clarendon Water Works Company is now sinking a twelve-inch well, and has made contracts for carrying it to a depth of 2,500 feet, if necessary. There is every reason to believe, however, that at a depth of not to exceed 200 feet an ample supply of flowing water should be obtained. Whether it will be salt or fresh cannot be foretold.

The first pronounced success in this direction was a well bored under the advice of the Survey at Hope Mills in Cumberland county, and this has been followed up by a number of successful borings in Cumberland, Robeson, Bladen, Columbus, Craven, Hyde, Edgecombe, and some other counties, as at Wrightsville Beach in New Hanover. Many of these being bored on the advice of the State Geologist.

The water at all of these deep wells does not overflow at the surface, but in such cases it comes sufficiently near so that it can be easily brought to the surface by the use of ordinary pumps. The quality of the water from the different wells is now being investigated by the Survey. It of course differs at different places, as it may be flavored with different mineral substances, but in all cases it appears to be free from such organic germs as could injure the health of the community.

Of course it is impossible to predict the exact character of the strata at different depths below the earth's surface, and inasmuch as the quantity of the under-ground waters varies greatly with the different kinds of strata—being more abundant in the loose, gravelly strata—it is impossible to predict at any exact point whether or not the well at that point at a given depth would be successful; and though in most cases our predictions as to water supplies have come true, yet in some cases the parties boring have failed to reach under-ground water supplies. This failure, however, might have been due to either of several causes: First, a water supply may not exist at that point; and in the second place the well may not be carried to a depth sufficient to reach the water supply; and in the third place, in boring the well the water-bearing stratum may be passed through by a careless operator without his knowing the fact. It is proposed to continue the investigations in connection with this work during the next year.

A large number of wells have been put down in nearly all of the eastern counties to depths of from 50 to 300 feet, and, while there have been some cases of failure to reach adequate water supplies, yet in a larger number of cases the experiments have been fairly successful, and the health of many communities has been greatly improved by the use of the water from these deeper wells.

DRAINAGE OF LANDS IN EASTERN COUNTIES.

This is another important subject for the eastern counties which has received attention from the Survey during the past year, and it is hoped to continue some investigations along this line during 1898. Our surveys have demonstrated the fact that in quite a number of cases the small lakes which exist in many of our eastern counties are sufficiently elevated above considerable tracts of land to permit the water being drained off from these lakes and swamps and being used for irrigation of crops which may be grown upon those lands. In connection with this investigation we are also endeavoring to show that in many cases there are swamp areas of land which by the combined use of ditches and cheap wind-mill pumps these lands may be relieved of their surplus of water during the wet seasons, and by the use of the same wind-mill pumps and surface reservoirs they may be irrigated in especially dry seasons, thus making it possible to use these lands for trucking or other agricultural purposes in such a way as to make them independent of the changing seasons. Several prominent truckers have shown their interest in this work and will co-operate with the Survey hereafter in carrying on experiments as to the best methods of accomplishing these results.

MAGNETIC SURVEY.

The attention of the Survey has been called many times by the courts, by local attorneys and by county surveyors, to the great difficulties which exist in this State in redetermining and relocating the boundary lines of tracts of land which were surveyed and recorded at different times in past years; and it must be apparent, especially to every attorney who has had experience in this line of work, as well as to every surveyor, that it is of great importance that there should be located at the court-house in every county some definite and permanent monument giving the direction of the true north and south, in order that any surveyor may go there at any time and determine for himself the amount of variation in his compass at that particular time. It is furthermore of great importance that there should be prepared maps and tables showing the variation of the compass needle in the several counties of the State at different times in the past, in order that knowing the present variation of the compass and the variation at the time of certain deeds describing surveys of a certain date, the surveyor can easily relocate the old lines.

Recognizing this need of more accurate surveys in locating the State and county and farm boundaries, and in the relocation of old boundaries, there was begun in May, 1898, in co-operation with the United States Coast Survey the working of a magnetic survey of the State. Thus far, our work has consisted mainly in the accurate location of a pair of magnetic meridian posts and of the establishment of a standard measure for surveyors' chains at the various county-seats in the State. On the plan of co-operation adopted, the United States Coast Survey has furnished us free of charge (for services) one of the most capable of its magnetic experts, Mr. J. B. Baylor, and a full set of the delicate instruments needed for this work. The several counties have been asked to appropriate the sum of $25 each to cover the various incidental expenses connected with the work, and the State Survey has agreed to defray such additional expenses as are not covered by the above. Some forty counties have accepted this proposition, and in these the work has been already completed. No doubt a number of other counties will agree to co-operate on this basis, and will authorize the work to be done early in the spring. It is hoped that this work can be continued until the meridian posts and standards of measure can be established in every county-seat in the State.

ROAD-BUILDING AND ROAD MATERIALS.

The question as to the best and most economic methods of improving the public roads of the State, the character and distribution of the best materials for macadamizing, have attracted an increasing amount of attention in all portions of the State. The Survey has not only carried on investigations concerning the road material, but has also given a large amount of information concerning the methods of road-building, and we have now nearly ready for publication a report giving a large amount of information concerning these subjects. Already more than thirty counties in the State have adopted, in part at least, the policy of working roads by taxation, and there is every reason to believe that at the approaching session of the General Assembly a still larger number of counties will ask to be added to this list.

The Survey has devoted a considerable amount of attention during the past two years to the investigation of these road materials in the different portions of the State, and the best methods of using these materials in the construction of better roads; and we have now nearly ready for the printer a new report (Bulletin No. 18) on this subject. This report, in addition to giving a description of the road materials and the best method of using them, will describe in some detail the general methods of building roads and of constructing the culverts and bridges, and judging from the numerous applications which have been received in advance, it is believed that this report will fill a much-needed want and will result in a decided benefit to the State. The State Geologist in his numerous trips has visited the different points where road-making was in progress, and in every way has rendered assistance to the road supervisors and superintendents in connection with the use of road materials and the relocation of roads, and has accepted, as far as consistent with his other duties, invitations to deliver addresses on road improvement in different portions of the State.

CHEMICAL WORK.

The chemical work of the Survey during the past two years, other than the examination of the mineral waters just mentioned, has been carried on by Dr. Charles Baskerville, and has consisted largely of the assays of gold and silver ores and the analyses of various mineral specimens.

OFFICE WORK.

The office work of the Survey during the year has consisted, as heretofore, largely in the arrangement of materials for the various reports and of the publication of these reports. Perhaps a still larger amount of time has been given to furnishing information concerning various subjects being investigated by the Survey, both to people living in the State and to outside parties desiring information.

Mr. R. H. Sykes, who, for several years, has served as stenographer of the Survey, resigned in June and his place was taken by Mr. A. E. Cates. Messrs. T. G. Pearson and R. B. Lawson have continued during the year to devote a portion of their time to clerical work in the office. The time of the State Geologist has been given partly to the preparation and editing of reports; partly to the large and growing correspondence of the Survey; and partly to active work in the field.

PUBLICATIONS.

Three reports have been published since the last meeting of the Board: That on the timber trees and forests, by Gifford Pinchot and W. W. Ashe; on the clay deposits and industries, by Heinrich Ries;

on the gold deposits and gold mining, by H. B. C. Nitze. These have already been widely distributed and have met with a hearty reception. The report on the water-powers is now nearly ready for distribution, and will make a volume of nearly 400 pages. The report on the road materials and road-building in North Carolina will be sent to the printers by the end of the present month. Reports on the mineral springs of the State, by Prof. F. P. Venable, and on forest trees suitable for shade in towns and cities and yards, prepared by Mr. W. W. Ashe, are ready for the printer.

Three additional reports, one on mica deposits, another on the gem-producing minerals of the State, and another, a gazeteer of the State, including elevations and brief descriptions of the counties, towns, mountains, rivers, etc., are now in course of preparation.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and subvouchers. These are grouped together and deposited with the Governor, as nearly as practicable at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such examination and approval the vouchers and itemized statements of expenditures are deposited with the State Auditor, where they are open to public inspection. The State Geologist gives bond in the sum of twenty-five hundred dollars; and at no time can the funds at his disposal for meeting such expenditures exceed this amount.

The accompanying statements show the expenditures of the Geological Survey for the two years ending November 30, 1898, grouped according to the subjects investigated during this time, the purposes for which funds are allotted, and the amounts paid each person connected with the Survey at any time during this period.

EXPENDITURES OF THE NORTH CAROLINA GEOLOGICAL SURVEY FOR THE YEAR ENDING NOVEMBER 30, 1898, GROUPED ACCORDING TO THE SUBJECTS INVESTIGATED:*

Subjects Investigated.	*Dec. 1, 1896, to Nov. 30, 1897.*	*Dec. 1, 1897, to Nov. 30, 1898.*
Topography	$1,858.88	$ 35.20
Forestry	835.90	1,046.00
Water-powers	544.23	683.85
Office assistance	383.35	881.65
Gold and Corundum Investigations	759.17	1,231.57
Photography supplies	352.26	85.44
Chemical work and supplies	1,019.43	1,031.51
Geological Board meetings	73.30	16.67
Clay Investigations	529.04	130.00
Salary of State Geologist	2,291.68	3,194.04
Postage and telegrams	139.20	183.82
Freight and express	114.22	190.97
General Mineral Explorations	788.55	643.64
Books, equipment and instruments	295.20	645.44
Total expenditures	$9,984.41	$9,999.80

AMOUNTS PAID FOR SERVICES TO THE SEVERAL PERSONS CONNECTED WITH THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1898:*

J. A. Holmes, State Geologist, 2 years, at $2,500	$5,000.00
H. B. C. Nitze, Assistant Geologist, 5 months, at $140	900.00
W. W. Ashe, Forester, 17 months, at $85	1,375.00
E. W. Myers, Water-powers Engineer, at $85 per month	835.00
Charles Baskerville, chemistry work	923.14
George B. Hanna, Special Assistant in Gold Investigations, at $5 per day	132.76
C. F. Horton, Topographer, at $5 per day	176.51
E. L. Faison, Rodman, 1 month	30.00
W. H. Ford, Topographer, at $5 per day	211.29
G. M. Coffey, Assistant in Office, 446 hours, at 12 1-2c	55.75
D. M. Cronin, Draughtsman, at $5 per day	32.50
H. Pheribo, laborer, at $20 per month	94.00
S. F. Telfair, Clerk Geological Board, 2 days, at $3	6.00
H. W. Durham, Topographer, at $5 per day	209.68
S. T. Kelsey, Road Engineer, at $5 per day	56.72
R. H. Sykes, Office Assistant, at $2 per day	549.25
W. Caldwell, laborer, at $1 per day	23.65
G. W. Godwin, laborer, at $1 per day	93.75

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*Itemized detailed statements and itemized receipted vouchers covering all these amounts are to be found deposited with the State Auditor.

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

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1900.

GEOLOGICAL BOARD.

Governor D. L. Russell, *ex officio Chairman,*	Raleigh.
J. Turner Morehead,	Leaksville.
Charles McNamee,	Asheville.

J. A. Holmes, *State Geologist,*	Chapel Hill.

TABLE OF CONTENTS.

PAGE.

Letter of Transmittal 5

Report of the State Geologist 7

- Mining, Water-power and Timber Developments 7
- Mineral Investigations 8
- Forest Investigations 10
- Water-power Investigations 11
- Mineral and Artesian Waters 14
- Good-roads Movement 14
- Co-operation of Government Bureaus 15
- Meridian Surveys and Monuments 15
- Soil Investigations 16
- Fish and Oyster Investigations 16
- Office Work 18
- Expenditures 19

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,

Raleigh, N. C., December 15, 1900.

To His Excellency, Governor D. L. Russell,
Raleigh, N. C.

Sir:—I have the honor to transmit herewith for your consideration and approval the administrative biennial report of the State Geologist for the two years ending November 30, 1900.

A summary of the expenditures of the Survey will be found at the end of this report; and the receipted itemized vouchers covering all expenditures have been approved by the Geological Board and deposited with the State Auditor.

The scientific and economic results of the Survey are being described in the special reports now being prepared and published.

Yours respectfully,

J. A. Holmes,
State Geologist.

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BIENNIAL REPORT OF THE STATE GEOLOGIST ON THE OPERATIONS OF THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1900.

By J. A. Holmes, State Geologist.

There has been considerable activity in industrial matters in North Carolina during the past two years; and this has manifested itself along their separate lines touched by the investigations of the Geological Survey, especially

MINING, WATER-POWER AND TIMBER DEVELOPMENT.

In mining this activity has been specially noticeable in connection with the deposits of iron, copper, mica, corundum and talc, but it has also extended to other ores and miscellaneous minerals. Activity in mining matters has been greater during the present year than at any time during the present decade.

In mining, the demand for iron, the resulting increase in its price and the starting up of the furnace at Greensboro has made it possible to operate some of the old mines that have been idle for years, and has also led to opening up of new deposits of iron ore concerning which little or nothing was known heretofore. Many inquiries have been received for information concerning these iron deposits, and a considerable amount of outside capital has been invested in the State in their development. Copper deposits have also been in demand during the year and some good copper mining deposits have been opened and are being worked in Person and Granville, Rowan and Ashe counties. In mica mining the work has been confined largely to Mitchell, Yancey and Haywood, Jackson and Macon counties, but some work has also been done in Cleveland and Stokes. Talc mining has been in progress in Cherokee, Swain and Moore counties. Corundum has been mined mainly in Jackson, Macon and Clay counties.

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In water-power development there has been more than usual activity on all of our larger streams, as on the Roanoke near Weldon; on the Neuse near Raleigh; on the Cape Fear at and above Smiley's Falls; and on its two tributary streams, the Deep and Haw; on the Yadkin in the vicinity of the Narrows, and several other points on the South Yadkin near its mouth; at several points on the Catawba and on Ivy river west of the Blue Ridge. In most of these places on the Neuse, the Yadkin and the Catawba the work has not yet gone further than surveys and plans; at others the work of developing is already in progress.

In timber developments there has also been unusual activity; and it is estimated that more than $2,000,000 has been invested in buying timber and timber lands in the eastern counties during the year. While the larger part of this activity has been devoted to the pine forests of this eastern belt, there has also been a considerable amount of money invested in the cutting of swamp timber along our eastern streams and the hardwood timbers in the middle and western counties.

One feature in connection with our timber interests deserves special mention, namely, the steady increase in the amount of timber used in the home manufacture of furniture and other articles.

The investigations of the Geological Survey have followed the same general lines as during the preceding year. The main features connected with this work are as follows:

MINERAL INVESTIGATIONS.

1. In the examination of miscellaneous mineral deposits, mainly by Dr. J. H. Pratt, considerable time has been spent upon abrasive minerals, corundum, emery and garnet, and nearly all the known localities have been examined. While many of these have proved of little or no importance, some give promise of considerable economic value. Up to the present time corundum (not including emery) has only been profitable for abrasive purposes where associated with peridotite rock; but now corundum is known to occur in considerable quantity in certain of the schists of Jackson and Clay counties. As yet, the percentage of corundum in the ore has not been practically determined. Experiments made upon the clean product of schists

from the Caney Fork, Jackson county, show this corundum to be of very good quality.

Regarding the corundum deposits of Canada it is yet too early to know to what extent they will affect the output of this State, but it is doubtful whether they will do so at all. The Canadian ores contain 14.7 per cent. of corundum, while there are a number of ores in North Carolina that will carry twenty to thirty per cent. of corundum. While at the Corundum Hill mine, Macon county, this past summer, the ore was tested and found to contain forty-five per cent. of corundum.

The data obtained in the examination of these corundum mines and localities are being used in the preparation of a bulletin on the corundum and the corundum-bearing rocks that is soon to be published.

The chromite and talc deposits have been examined and a short paper has been published on the former. The manuscript for an economic paper on the talc deposits is nearly completed and will appear about the last of January. The talc deposits of the United States that have been supplying the market are becoming exhausted and a new source of supply is needed, or a substitute for the mineral. It is expected that the extensive beds of agalmatolite of Chatham and Moore counties will be largely used in the place of talc, as it has many of the physical properties of talc, and especially of those that make this mineral of value for its present uses. Already these deposits of agalmatolite are attracting the attention of capitalists, and there is very good reason to believe that they will be extensively mined. They have been examined and will be described in the paper on talc.

A number of gem mines and localities have been examined, of which the most interesting is the ruby mine in Cowee Valley, Macon county. No work was done at this mine during the past year. But preparations are being made to begin operations again in the spring. None of the products of this mine have as yet been put on the market, although a number of very fine gems have been found. The Rhodolite mine on Mason branch, Macon county, has been worked most of the year with very good success. The product of this mine is also being held back, so that at the present time there are very few rhodolites on the market. Both of these mines are owned by the American Mining and Prospecting Company of New York.

The Littlefield beryl mine has again been opened and preparations are on foot to thoroughly develop this mine in the spring.

Another locality has been discovered for the gem hiddenite which is almost adjoining the present well-known mine from which this beautiful gem has been obtained. The property is supposed to have been secured by the company who owned the original mine.

If possible, the bulletin on the gems of North Carolina will be brought out during the coming year. There is considerable interest becoming manifest among gem dealers for the development of the gem localities of the United States, and North Carolina, which is now known as the gem State on account of the number and variety of the gems that it has produced, will be one of the most attractive places for the prospector.

Collections of typical North Carolina minerals have been made of from twenty to thirty specimens each, and these have been sent to about fifteen of the colleges and schools of the State. This division also co-operated with the State Museum in obtaining mineral specimens for that department.

A report on the mining industry of the State during 1899 was prepared by Dr. Pratt for the Commissioner of Labor and Printing, but the report of the mining industry of the State during 1900 will be published as one of the series of *economic papers* of the Survey. The results of the investigation by Dr. Pratt into the talc deposits of the State have been published as *Economic Paper No. 3.*

FOREST INVESTIGATIONS.

2. In the forestry investigations, under Mr. W. W. Ashe, the work has been continued mainly in the eastern counties, with the view of determining the rate of growth of the short-leaf pine under different physical conditions, this being a part of the general purpose of our forestry examination, which is to determine what forest growth of commercial value is best adapted to the different conditions of soil, moisture, etc., as they exist in different regions. The short-leaf, or loblolly pine, in the eastern counties, is to-day undoubtedly our most valuable commercial tree. The investigation as to this tree and as to how forests of it may be propagated to the best advantage was begun in the summer of 1891, the Forestry Division of the United States

Department of Agriculture, co-operating with the Geological Survey in this examination during the spring and summer of the present year. Mr. Ashe was assisted by Mr. J. A. Caldwell, Jr., of Salisbury, and Mr. H. M. Curran of the Agricultural and Mechanical College, Raleigh, and for a short time these were further assisted by two graduate students from the Agricultural and Mechanical College. They have traversed each of our eastern counties, investigating the density and rate of growth of the pine on different soils, as far as possible, and of the amount of standing timber of different sizes on these pine lands. The results of these examinations are now being tabulated, and the report on the same will be prepared by Mr. Ashe during the winter and spring months. At the present time the Survey is co-operating with the State Board of Agriculture in examining the lowlands bordering the Roanoke and other eastern streams, with a view of determining whether it will pay better to reclaim these lands for agricultural purposes or to use them for the growth of commercially valuable forest trees; and Mr. Ashe is now on the Roanoke river engaged in examining these lands bordering that stream.

WATER-POWER INVESTIGATIONS.

In connection with the water-power investigation (of which Mr. E. W. Myers is in charge), the work undertaken in the fall of 1895 and in the spring of 1896 by the North Carolina Geological Survey and of the United States Geological Survey, working in co-operation, has been vigorously prosecuted during the past two years along the original lines laid out for it. Stations have been established and maintained on the following rivers: On the Roanoke river near Neals; on the Dan and Stanton rivers just above the junction to form the Roanoke; on the Tar river at Tarboro; on the Neuse river near Selma; on the Cape Fear river at Fayetteville; on the Deep river near Moncure; on the Yadkin river near Salisbury; on the Pee Dee river near Norwood; on the Catawba river at Catawba; on the Broad river near Gaffney, S. C.; on the French Broad river at Asheville; on the Tuckaseegee river at Bryson City; on the Little Tennessee river at Judson, and on the Hiawassee river at Murphy, thus covering all the principal water-power streams of the State. No effort has been made to establish these stations on the tributary streams, since the data gathered from the main streams are applicable to the tributaries as well.

At all these stations a man has been employed to take daily readings of the stage of the water-surfare on a permanent gauge established by the Survey, and to make a record of the same in a book furnished for the purpose. Weekly reports are made to the office of the Survey of this and all other data which may be obtained during the week relative to the flow of the stream and the causes affecting it. At all these stations instrumental gaugings of the volume of flow have been made from time to time, these varying in number from four to nine for each station during the current year. Eighty-six measurements were thus made during the year 1899. From these measurements the station-rating tables are constructed, giving the volume of flow for every gauge-height that the river has reached during the year. From these tables and the record of the daily gauge-pipe, when extended over a sufficiently long period, the value of the river as a source of water-power can be accurately determined.

Although these measurements were undertaken such a short time ago, already their value is very great and increases greatly with every year over which they are extended. Accurate data of the flow of any Southern stream was not available previous to the inception of this work, and such information was very badly needed on account of the beginning made some few years ago of the development of some small part of the vast undeveloped water-power of the South. From the beginning the development of the water-power is every year growing at an increasingly rapid rate, and thus every year the information derived from these measurements is more eagerly sought for. Much information concerning water-powers and the rate and volume of the flow of the various streams has been furnished during the year to investors and those contemplating the development of water-power in the near future.

It has been planned to extend the scope of the work so as to make it include data of more thoroughly scientific value than any heretofore obtained, which have been of more decided economic value. Thus it is proposed to obtain the surface slope of the stream at several stations, and in this way discover more accurately the relation existing between this factor, the character of bed and bank, and the volume of the flow.

The stream investigations in the western portion of the State were carried on with special energy during the past several months owing to the bearing that these investigations would have on the establishment of the proposed National Forest Reserve in Western North Carolina and adjacent States.

Arrangements have also been made with the U. S. Weather Bureau whereby additional rain-fall and temperature stations will be established within the drainage basins of several streams in this State, thus making it possible to more accurately investigate the relation between the amount and distribution of the rain-fall and the annual run-off of the streams.

Experiments have already been undertaken to determine the relative run-off from areas of widely different geologic structure, and these will be further prosecuted during the year.

Mr. Myers has been assisted in this work by Messrs. H. A. Pressey, Cleveland Abbe, Jr., L. V. Branch, N. C. Curtis and Ernest Graves.

The larger part of the information concerning the flow of the streams which was gathered prior to January 1, 1899, has been published in Bulletin No. 8 of the Survey series.

In connection with both the forestry and water-power investigations, it may be of interest to mention the work which is now being done under two of the government scientific bureaus, co-operating with the State Geological Survey in the mountain counties of Western North Carolina and adjacent States, with a view of selecting a location for the proposed Appalachian Forest Reserve in this region. Two parties of three men each have already begun the investigation of the amount of water flowing through and out of this mountain region, with the view of demonstrating to the country the importance of protecting more or less of forest growth about the head-waters of a large number of our important rivers which have their sources in this region, and during the summer and autumn months there will be carried on under the supervision of the Secretary of Agriculture a careful examination of the forest resources of this region.

MINERAL AND ARTESIAN WATERS.

In connection with the examination of the more important mineral waters of the State, samples of these have been collected by special agents of the Survey, who at the same time gathered data as to the volume of flow and temperature of the water at each of the springs and wells. These analyses have been made by Prof. F. P. Venable, and his report covering this subject is now ready for publication.

In the way of additional chemical work the analyses of a number of ores and miscellaneous minerals have been made by Dr. Charles Baskerville.

The investigation of the artesian water supplies in the eastern counties has been continued by the State Geologist, who has examined during the year a considerable number of these wells, and he has also made a special study of geological formations along the Cape Fear river, with a view of possible water-supplies from them. He has now in preparation a report embodying all the available data concerning the deep-well supplies of water in the eastern counties. Perhaps the most notable of the deep wells now being sunk is that which is being drilled by the Federal Government at Fort Caswell at the mouth of the Cape Fear river.

GOOD-ROADS MOVEMENT.

The Geological Survey has continued to take an active interest in the question of public road improvement. At intervals during the year the State Geologist has visited almost every county in the State where this work has been in progress, and has rendered such service as he could in the way of examining materials best suited for the road-building, and giving information and advice to those in charge of the same. He gave a public address before the last General Assembly on this subject, and has since given a number of similar lectures in different portions of the State. During the second week in last July he held a Road-builders' Institute in Charlotte, which was attended by nearly all the supervisors of roads in counties where efforts are being made in the direction of highway improvement, and also by a number of road supervisors from South Carolina. He has also prepared and will publish during the winter a report of road materials and road-building in North Carolina.

CO-OPERATION OF GOVERNMENT BUREAUS.

Several of the government scientific bureaus have co-operated with the State during the past year with considerable liberality. First among these should be mentioned the U. S. Geological Survey, which has had during a larger part of the season two full topographic parties in this State, and these have surveyed and are now surveying maps for the 1,198 square miles territory lying mainly in Buncombe, Yancey, Burke and McDowell counties. This will be published in the Mount Mitchell atlas sheet. The careful and accurate manner in which this work has been done leaves little to be desired except in the way of pushing the surveys forward more rapidly. Some work has been done towards the revision of the Morganton atlas sheet. About one-fourth of the total area of the State has now been surveyed and mapped. In geological work, Mr. Arthur Keith, one of the geologists of that survey, has been continuously engaged for several years in examining and mapping the rock formations of the western counties.

MERIDIAN SURVEYS AND MONUMENTS.

The Coast and Geodetic Survey has also co-operated with us in the establishment of magnetic meridian monuments at the various county-seats and in the making of a general magnetic survey. This work has been generally a triple system of co-operation. The Government Survey has paid the salary and generally the *per diem* expenses of the expert in charge of this work, Mr. J. B. Baylor. The several counties have paid certain incidental expenses, such as the cost of the meridian monuments and the immediate work of setting them in place, this cost, as a rule, being less than fifteen dollars per county. The State Geological Survey has paid other expenses of the work, and during a portion of the year has also paid the *per diem* living expenses of the engineer, and the full incidental expenses connected with the setting up of the monuments in cases where the counties failed to do this. These monuments have been erected at all the county-seats, at the State University and the Agricultural and Mechanical College, the work having been completed in November, 1900. North Carolina now has within her borders a larger number of meridian stations than any other State. The general magnetic conditions have been examined at every county-seat in the State and at a few other points of interest. The true north and south lines have been determined at each of these county-seats and have been marked at each by two granite posts set 300 to 600 feet apart. So that at or near every county-seat in the State surveyors and engineers can now test the accuracy of their compasses with ease and certainty. Maps have been constructed and will soon be published showing the declination (or variation) of the compass, and a State survey report will describe in detail the general magnetic condition of the State and will give specific directions to engineers and surveyors as to how to use the meridian monuments and maps to the best advantage. Furthermore, at the county-seats a standard measure has been determined which will enable the surveyors to test the accuracy of their measuring chains. The magnetic observations upon which this report is based have been made in a highly creditable manner by Mr. J. B. Baylor of the U. S. Coast and Geodetic Survey.

SOIL INVESTIGATIONS.

The soil investigations which were inaugurated during the spring season by the U. S. Department of Agriculture and the Geological Survey co-operating were carried on during the summer and autumn seasons, the work being limited largely to a belt 10 miles wide, along the railway line from Raleigh to New Bern, for the reason that this was the only area of which sufficiently accurate maps could be easily prepared. During the late autumn season, however, work was begun by the U. S. Geological Survey with a view of mapping at an early date a considerable number of counties lying in central Eastern North Carolina. During the next year it is proposed to continue the examination of the soils on a large scale. The object of this work is to determine the character and distribution of the different varieties of soil in Eastern North Carolina, and to determine further the character of the crops and forest growth best adapted to each of these varieties.

FISHERY AND OYSTER INVESTIGATIONS.

The United States Fish Commission has also co-operated with the Survey in a most liberal way, as follows:

1. In the establishment of a fish hatchery at Edenton, where a lot

has been purchased, buildings erected and a regular hatchery station established, at a cost of $21,000; and from this a large number of young shad and other fish will turned loose in the North Carolina waters each year.

2. In the establishment of a biological laboratory at Beaufort, at a cost of $31,000, which has for its object the investigation of marine fishes, oysters, clams and other forms which are connected directly or indirectly with the fishery interests of our sea coast region. During the present year this laboratory was opened only during the summer months, but in the future it is hoped that it can be kept open throughout the entire year. Prof. H. V. Wilson, the Biologist of the Geological Survey, served as Director of this laboratory without pay.

3. In connection with oyster investigations in our eastern waters, the United States Fish Commission, at the request of the Geological Survey, sent to Beaufort in October, 1899, the United States steamer Fish Hawk, with a crew of forty men, including several oyster experts, for the purpose of making a thorough examination of the North Carolina oyster beds, with especial reference to the possibility of successful oyster planting in these waters. Dr. Caswell Grave of Johns Hopkins University was appointed Assistant Biologist of the Survey and employed as additional expert on board the Fish Hawk in the months of October and November at a salary of $125 per month and expenses, of which amount $100 and expenses was paid by the United States Fish Commission. Early in January the Fish Hawk was transferred to Pamlico Sound, where, during that and the three following months, her officers and men, together with several special experts, continued the oyster investigation in different portions of that region. The reports embodying the results of these investigations have already been submitted to the United States Commissioner of Fish and Fisheries, and at an early date will be published both by the United States Fish Commission and the Geological Survey. Towards the end of April the Fish Hawk was transferred to Chesapeake Bay, where it was arranged that she should co-operate in the hatching out of young shad. Dr. Caswell Grave, who, from the first of October to this time had been the biological expert in these investigations on board the Fish Hawk, was transferred to Beaufort, N. C., where, during May and early June, he has inaugurated an experimental oyster farm, and in co-operation with the United States Fish Com-

mission, he continues to make a careful study of rate of growth of the oyster under different conditions. Among the results already shown by these investigations is that, whereas, in the majority of cases, the oysters planted through private enterprise have not thrived sufficiently to serve as a commercial basis, yet in many places the conditions are favorable, and over considerable areas the planting of oysters by individuals or corporations may prove highly successful and the investment quite profitable.

In order for the Fish Hawk, which draws nearly eight and one-half feet of water, to enter Pamlico Sound it was necessary for her to go around Cape Hatteras to Norfolk, and thence southward through Albemarle and Chesapeake Canal. Ordinarily the canal and towing fees in bringing the Fish Hawk through would amount to about four hundred dollars for the round trip, but the Canal Company has generously waived its charges in order to help carry forward these investigations, and the towing company has also generously offered to tow the Fish Hawk in and out through the canal at about actual cost of doing this.

These investigations of the oyster beds of the State have not yet been completed, and it is hoped that the arrangement for their continuance can be made during the year 1901. It is believed, however, that the results already obtained will have an important bearing upon the future development of the oyster industry of the State. A preliminary report embodying the result of these investigations up to date is now ready for publication.

OFFICE WORK.

The office work of the Geological Survey has received the personal attention of the State Geologist. And in this he has been assisted by Mr. A. E. Cates as Stenographer and Clerk, and from time to time by Messrs. R. B. Lawson, T. Gilbert Pearson and C. W. Sapp. Many specimens of minerals have been examined by the State Geologist and Dr. Pratt, and reports are sent out free to the parties forwarding the same. The increasingly large correspondence of the office has been attended to as promptly as circumstances will permit in view of the frequent absences from the office of the several officers of the Survey.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and subvouchers. These are grouped together and deposited with the Governor, as nearly as practicable at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such examination and approval the vouchers and itemized statements of expenditures are deposited with the State Auditor, where they are open to public inspection. The State Geologist gives bond in the sum of twenty-five hundred dollars; and at no time can the funds at his disposal for meeting such expenditures exceed this amount.

The accompanying statements show the expenditures of the Geological Survey for the two years ending November 30, 1900, grouped according to the subjects investigated during this time, the purposes for which funds are allotted, and the amounts paid each person connected with the Survey at any time during this period:

EXPENDITURES OF THE NORTH CAROLINA GEOLOGICAL SURVEY (INCLUDING BOTH SERVICES AND EXPENSES) FOR THE TWO YEARS ENDING NOVEMBER 30, 1900, GROUPED ACCORDING TO THE SUBJECTS INVESTIGATED:*

Subjects Investigated.	*Dec. 1, 1898, to Nov. 30, 1899.*	*Dec. 1, 1899, to Nov. 30, 1900.*
Forestry Investigations	$ 927.64	$ 643.17
Water-powers Investigations	1,043.79	1,028.70
Fish and Oyster Investigation	....	890.51
General Explorations	626.32	1,208.63
Corundum and General Mineral Investigation	1,029.11	1,186.51
Chemical work and supplies	697.75	518.10
Geological Board meetings	25.00	264.65
Magnetic Survey	949.05	420.53
Photography and illustrations	529.27	213.39
Equipment and office supplies	340.40	287.86
Telegrams, freight, express and postage	370.34	245.82
Clerical assistance	550.60	666.00
Salary State Geologist	2,291.71	2,291.68
Topography	....	133.75
Artesian Well Investigation	208.85	....
Good-roads Investigations	410.00	....
Totals for each year	$9,999.83	$9,999.30
Total for the two years		19,999.13

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AMOUNTS PAID FOR SERVICES TO THE SEVERAL PERSONS CONNECTED WITH THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1900:*

J. A. Holmes, State Geologist, 2 years	$4,583.39
J. H. Pratt, Assistant Geologist, 16 months, at $125	2,000.00
E. W. Myers, Water-powers Engineer, at $85 per month	1,185.89
W. W. Ashe, Forester, at $85 per month	1,358.17
Charles Baskerville, chemical work, 2 years	456.50
F. P. Venable, chemical work, 2 years	390.00
A. E. Cates, Clerical Assistant, at $60 per month	770.00
C. C. Jones, photograph work, at $3.30 per day	31.90
M. L. Britton, Mineral Water Assistant, 6 days, at $1	6.00
N. L. Shaw, Janitor, 17 months, at $10	170.00
T. G. Pearson, Clerical Assistant, 6 months, at $20	120.00
S. L. Herndon, carpenter work	40.37
John H. Sweeney, Assistant in Artesian Well Investigations, at $30 per month	232.00
R. B. Lawson, Office Assistant, at $15 per month	155.00
Collier Cobb, Assistant Geologist, 2 days, at $2.50	5.00
J. B. Howell, Stenographer, 2 3-4 days, at $2	5.50
L. C. Glenn, Office Assistant, 54 days, at $3	162.00
George N. Coffey, Office Assistant, 3 days, at $1	3.00
B. C. Best, Office Assistant, 7 1-2 days, at $2	15.00
Miss Riddick, Stenographer, 2 months, at $23.75 per month	47.50
H. M. Curran, Assistant in Forestry, 20 days, at $1	20.00
John Erbach, photograph work	17.40
Miss M. S. Birdsong, Stenographer, 2 1-2 days, at $2	5.00
C. L. Coon, Office Assistant, 2 1-2 days, at $2	5.00
C. W. Sapp, Office Assistant, 8 1-2 months, at $20	165.00
R. E. Shuford, Assistant in Water-powers Investigations, 35 days, at $3	105.00
Miss L. D. Rives, Stenographer, 2 1-2 days, at $2	5.00
Caswell Grave, Expert in Fish and Oyster Investigations, 6 3-4 months, at $100 per month	675.00
James Higgs, laborer, 5 days, at $1	5.00
J. V. Lewis, Assistant Geologist, 10 days, at $5	50.00
W. J. Curfman, Good-roads Assistant, 13 days, at $1.75	22.75
S. L. Alderman, photograph work, 2 days, at $4	8.00
Baylus Cade, Secretary Geological Board, 2 years, at $50 per year	100.00
W. M. Adams, laborer, 3 days, at $1	3.00
R. H. Williams, laborer, 4 days, at $1	4.00
C. Richardson, laborer, 5 days, at $1	5.00
M. A. Moore, laborer, 7 days, at $1	7.00
F. Glover, laborer, 2 days, at $1	2.00
J. H. Barber, laborer, 4 days, at $1	4.00
W. B. Nichols, laborer, 3 days, at $1	3.00
J. H. Faber, protograph work	8.40
J. W. Turrentine, Assistant in Fishery Investigations, 2 months, at $40	80.00
Total expenditure for services, 2 years	$13,036.77
Total for traveling, field and office expenses	6,962.36
Total for all expenditures, 2 years	$19,999.13

02

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, STATE GEOLOGIST.

BIENNIAL REPORT

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GEOLOGICAL BOARD.

Governor C. B. Aycock, *ex officio Chairman*,	Raleigh.
J. Turner Morehead,	Leaksville.
Charles McNamee,	Asheville.

J. A. Holmes, *State Geologist*,	Chapel Hill.

TABLE OF CONTENTS.

Letter of Transmittal 5
Report of the State Geologist 7
  Miscellaneous Mineral Resources 7
  Water-power Investigations 7
  Soil Examinations 8
  Road-building Investigations 9
  Forests of the Southern Appalachians 9
  Geology of the Mountain Counties 11
  Topographic Surveys 11
  Oyster and Fish Investigation 12
  Office Work 13
  Expenditures 13

BIENNIAL REPORT OF THE STATE GEOLOGIST ON THE OPERATIONS OF THE GEOLOGICAL SURVEY OF NORTH CAROLINA DURING THE TWO YEARS ENDING NOVEMBER 30, 1902.

By J. A. Holmes, State Geologist.

MISCELLANEOUS MINERAL RESOURCES.

An investigation into the miscellaneous mineral resources of the State has been continued during the year by Dr. J. H. Pratt, the Mineralogist of the State Survey. These examinations have been distributed through nearly all the mountain counties and they have also extended through a number of the Piedmont and midland counties. The general purpose of this work is, as far as may be possible, to determine the specific distribution of each species of mineral found in the State, the extent, mode of occurrence and value of each such mineral deposit. It is expected that a report of 300 to 400 pages embodying the results of these investigations will be ready for publication toward the end of the year 1903.

The chemical work of the Survey during the year has not been extensive, but such analyses of ores and minerals as have been found necessary have been made by Dr. Charles Baskerville, in the chemical laboratory of the University, and by the chemist of the Department of Agriculture at Raleigh.

WATER-POWER INVESTIGATIONS.

The water-power investigations have been continued during the year on much the same basis as during the past several years; the United States Geological Survey co-operating with the State Survey in all of the general examinations. Stations at which are made daily measurements as to the height of the water in the streams have been maintained during the year on the Roanoke river at Neals, on the Cape Fear river at Fayetteville, on the Yadkin river at Salisbury and Siloam, on the Catawba river near Morganton and at Catawba Station, on the Broad river near the South Carolina line, on the French Broad river at Asheville, on the Tuckaseegee river at Bryson City, on the Little Tennessee river at Judson, on the Hiawassee river at Murphy, and on several of the smaller mountain streams. The observers who make the daily measurements at each of these stations are paid largely by the United States Geological Survey, but the results are turned over to the State Survey. All of these measurements are made under the general supervision of Mr. E. W. Myers, the engineer of the State Survey, who also makes at intervals of once every month or every two months careful measurements with electric meters of the flow and volume of water at each of these stations. This work makes it possible for us to calculate with approximate accuracy the amount of water-power in each of these streams on each day during the year for one foot of fall. Measurements of the amount of fall at different points in each of these important streams make it possible to determine with approximate accuracy the amount of water-power which can be developed on each of these streams.

SOIL EXAMINATIONS.

The investigation of the soils of the State is in a measure a geological problem, inasmuch as the soils themselves are geological products, and they are being examined in their relations to the rocks from which they were formed. A systematic examination of these soils was begun during the year 1900 through an arrangement of cooperation between the State Geological Survey, the State Department of Agriculture and United States Bureau of Soils; the purpose of this investigation by the Geological Survey being to determine the origin, character and variations in the soil in different parts of the State, with a view to enabling the Agricultural Department to determine through its agricultural experiments the best methods of fertilizing and otherwise improving the soils and to discover the crops to which they are best suited. I regard these examinations as the most important that have been inaugurated in the State, and I believe that the results of these investigations will prove of inestimable and permanent value. It was considered highly desirable that these soil investigations should begin in the eastern counties of the State, for the reason that the soils in that region are more uniform in character and distribution, and consequently the results obtained are more extensive in their application. But the difficulty met with in beginning the investigations in that region was the lack of accurate maps. These maps were found to be necessary not only for the soil examinations, but also for determining the boundaries of the different character of soils, the possibilities of drainage, irrigation, etc. Consequently an arrangement was made between the United States Geological Survey and the Department of Agriculture by which careful surveys of the eastern counties of the State should be made. This work has progressed during the past year in an eminently satisfactory manner, and arrangements have been made to continue it during the coming year.

ROAD-BUILDING INVESTIGATIONS.

In connection with the investigation of the road materials of the State a considerable amount of attention has been given to the general subject of improved road-building in North Carolina. Meetings have been arranged at a number of the county-seats and addresses have been given there by the State Geologist. In connection with the good-roads movement in North Carolina it is worthy of mention that the Southern Railway good-roads train spent several days at Winston-Salem during the first week in November, and during the following week spent several days in the vicinity of Asheville, in both these places building a sample macadam road and holding a good-roads convention, which in each case was largely attended. These and other good-roads meetings held in the State during the past year have undoubtedly exercised a decidedly beneficial influence in promoting the movement for better public highways.

FORESTS OF THE SOUTHERN APPALACHIAN MOUNTAINS.

The forest and timber investigations have been carried on during the year through a co-operative arrangement between the State Geological Survey, the Government Forestry Bureau and the Government Geological Survey. Mr. W. W. Ashe, the forester and timber expert of the State Geological Survey, has completed his investigation into the pine forests of the eastern counties and his report embodying the results of his examinations will be ready for publication during the next summer season. His expenses, and during a portion of his time, his salary were paid by the United States Department of Agriculture. During a portion of the year he has co-operated in the investigation of the hardwood forests of the mountain counties. This latter investigation, however, has been done largely by Mr. H. B. Ayres of the United States Geological Survey, they paying his salary, while the State Geological Survey has paid the larger part of his field expenses. This investigation into the forest condition of the western counties has been carried on mainly in connection with the movement for the establishment of a National Forest Reserve in the mountain counties of Western North Carolina and adjacent States, and the immediate results of the investigation have been turned over to the United States Department of Agriculture and embodied in a report by the Secretary of Agriculture, which will be transmitted to Congress at an early date.

It should be added in this connection that with a view to making the above-mentioned report as complete as practicable, the investigation into the geology, topography and general hydrographic conditions in the Southern Appalachian mountain region has been continued during portions of the past year by the United States Geological Survey, co-operating with the State Survey, and during the months of July and August the special photographer of the United States Forestry Bureau was sent to North Carolina to co-operate with Mr. Ashe of this Survey in securing an elaborate series of photographs illustrative of the forests and agricultural conditions in the Southern Appalachian region and mainly in Western North Carolina.

In the investigation of the general natural history resources of the State a study of the miscellaneous botanical resources of the mountain counties has been inaugurated during the year under Mr. George F. Atkinson, Professor of Botany in Cornell University. Mr. Atkinson spent portions of the months of July, August and September in Watauga, Mitchell and Yancey counties making examinations and collecting materials for his report. He was assisted in this work by Dr. E. J. Durand. The arrangement made with both Professor Atkinson and Dr. Durand was that their expenses should be paid by the Survey, but they receive no compensation except sufficient to cover their necessary traveling expenses. Of the specimens collected by them, one set goes to Cornell University and all other collections come to the State Geological Survey.

GEOLOGY OF THE MOUNTAIN COUNTIES.

The investigation into the general economic geology of the mountain counties has been continued during the past two years on a basis of co-operation between the United States Geological Survey and the State Survey. The field work has been done mainly by Mr. Arthur Keith and Mr. H. S. Gale of the United States Geological Survey, and by Dr. J. H. Pratt and the State Geologist, representing the North Carolina Geological Survey. Mr. Keith and Mr. Gale have devoted especial attention to the study of the geological structure and history of the region, while Dr. Pratt and the State Geologist have examined more carefully the economic geology and miscellaneous mineral resources.

Dr. Pratt, with the assistance of Prof. J. V. Lewis, has practically completed the preparation of the report on corundum and its associated rocks and minerals; and the State Geologist has nearly completed a report on the mica deposits. Mr. Keith and Mr. Gale have continued their work of mapping the geological formations, and several of the atlas sheets, embodying all available information concerning these and the mineral resources and water-powers of the region, are now being prepared for publication.

TOPOGRAPHIC SURVEYS.

A considerable amount of topographic work has been done by the United States Geological Survey, co-operating with the State Survey, both in the eastern and in the western counties. In the western counties a considerable amount of work has been done in connection with the topography and forest conditions, with especial reference to the creation there of the Appalachian Forest Reserve. A considerable amount of topographic work has also been done in the eastern portion of the State, especially in the vicinity of Newbern, Trenton, Edgecombe, Rocky Mount, Tarboro, Kenly and Hertford.

These maps of the eastern counties are engraved on a scale of one mile to the inch and with contour intervals of ten feet, so that they have a degree of accuracy considerably beyond that of ordinary topographic atlas sheets. The contour lines show the elevation of the surface at different points above tide-water, the scale of the map will indicate the distance, and the contour lines will indicate further the feasibility of drainage of the land. These maps will be used as a basis not only for locating the geological formations, but also as a basis for the examination and classification of the soils of the region and a study of the under-ground water conditions.

OYSTER AND FISH INVESTIGATION.

The oyster examinations and the general biological survey of the eastern sounds which were begun in October, 1900, through an arrangement of co-operation between the United States Fish Commission and the State Geological Survey, have been continued at intervals during the past year. The observations on the oyster beds which were planted during these examinations in the vicinity of Beaufort have been continued during the summer season by Dr. Caswell Grave of Johns Hopkins University, who was associated with this work during the preceding year. During the months of June and July, Dr. Grave was assisted in this work at intervals by Dr. Glaser of Columbia University, and by Dr. Graham of the University of Alabama. Dr. Grave will continue his investigations of the oyster beds in the vicinity of Beaufort during the summer season of 1902, and at the end of that season his report and also the report of the Fish Commission experts, who have been co-operating in the examination of the oyster beds in Eastern North Carolina, will be published by the Survey.

The establishment of the Marine Biological Laboratory at Beaufort and of the Fish Hatchery Station at Edenton will greatly facilitate the general investigation of the biological conditions of the Eastern North Carolina sounds, and it is hoped that these investigations will lead to results of great benefit in connection with the development of the oyster and general fishery interests of the State.

OFFICE WORK.

The office work of the Geological Survey has been carried on under the immediate direction of the State Geologist, but in this he has been assisted largely by the chief clerk of the Survey, Mr. R. H. Sykes. In the clerical work Mr. Sykes has been assisted at intervals by special stenographers, who have been employed when necessary for a few hours or a few days at a time; and in keeping track of the records of the river measurements, he has been assisted regularly by Mr. John S. Henderson, Jr.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and subvouchers. These are grouped together and deposited with the Governor, as nearly as practicable at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such examination and approval the vouchers and itemized statements of expenditures are deposited with the State Auditor, where they are open to public inspection. The State Geologist gives bond in the sum of twenty-five hundred dollars; and at no time can the funds at his disposal for meeting such expenditures exceed this amount.

The accompanying statements show the expenditures of the Geological Survey for the two years ending November 30, 1902, grouped according to the subjects investigated during this time, the purposes for which funds are allotted, and the amounts paid each person connected with the Survey at any time during this period:

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NORTH CAROLINA GEOLOGICAL SURVEY.

J. A. HOLMES, State Geologist.

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GEOLOGICAL BOARD.

Governor C. B. Aycock, *ex officio Chairman*,	Raleigh.
J. Turner Morehead,	Leaksville.
Henry E. Fries,	Winston-Salem.

J. A. Holmes, *State Geologist*,	Chapel Hill.

TABLE OF CONTENTS.

PAGE.

Letter of Transmittal 6

Report of State Geologist 7

Road Materials and Construction 7
Mineral Investigations 9
Building Stone Investigations 11
Geology of the Mountain Counties 12
Investigation of Copper Deposits 14
Topographic Surveys 16
Soil Examinations 17
Water-power Investigations 20
Forestry Investigations 21
Fish and Oyster Investigations 21
State Mining Exhibit at St. Louis 22
Personnel of the Geological Survey 24
Reports to be Published 27
Benefits resulting from the work of the Survey 27
Expenditures of the Geological Survey 29

LETTER OF TRANSMITTAL.

North Carolina Geological Survey,
Raleigh, N. C., December 17, 1904.

To His Excellency, Governor Charles B. Aycock,
Raleigh, N. C.

Sir:—I have the honor to submit for your approval and for publication the administrative biennial report of the State Geologist, covering the operations and expenditures of the Geological Survey during the two years ending November 30, 1904.

In this connection I beg to express my appreciation of the active and continued interest you have shown in this work throughout the four years of your administration.

At the end of this report will be found a list of reports on special subjects now ready for publication. The preparation of these reports has been delayed by the need of continued explorations over large areas; but these reports will be followed by others, so that from now on at intervals for several years the people of the State will be given the full results of these explorations and investigations in North Carolina, which are being carried on by the State Survey with the active co-operation of the United States Geological Survey, the United States Bureau of Fisheries, the United States Bureau of Soils and the North Carolina Department of Agriculture.

In conclusion, I may call your attention to the fact that this work has to do not only with our present development, but, what is of still more importance, its results will serve as a basis for the future growth and the larger industrial life of the Commonwealth.

With great respect, I have the honor to remain,

Yours truly,

J. A. Holmes,
State Geologist.

North Carolina State Library
Raleigh

BIENNIAL REPORT OF THE STATE GEOLOGIST ON THE OPERATIONS OF THE NORTH CAROLINA GEOLOGICAL SURVEY DURING THE TWO YEARS ENDING NOVEMBER 30, 1904.

By J. A. Holmes, State Geologist.

The work of the North Carolina Geological Survey during the two years ending November 30, 1904, has included a variety of subjects connected with the industrial development of the State, as is indicated by the following synopsis of the same:

ROAD MATERIALS AND CONSTRUCTION.

In connection with the good-roads movement in the State: The investigation of the road-building materials by the State Geologist, which has been in progress during the past several years, during 1903 was extended through many of the middle and western counties of the State by Mr. F. B. Laney and Mr. T. L. Watson, acting as Assistant Geologists. The demand for information on this subject is increasing as the work of road-building progresses; and a special report covering the results of these investigations will soon be ready for publication.

Good-roads meetings were held at a number of places during 1903; newspaper bulletins were issued to practically all of the papers, at intervals during the year; and from time to time during both years the Road Engineer of the Survey, Mr. W. L. Spoon, not only attended such public meetings as were held, but visited the county authorities in many of the counties, giving them the benefit of his advice in all matters pertaining to the building and repair of the public roads. He has aided the county authorities by laying out new roads, changing the location of old roads where such changes were needed, discovering new deposits of suitable materials for road-building uses, and showing them how the local materials can be used to the best advantage for road-building purposes.

In the eastern counties, Craven, Wayne, Edgecombe, Nash, Northampton, Wilson, Johnston and others, this work has developed particularly along the lines of proper drainage and the proper admixture of sand and clay on the road surfaces. In these and other eastern counties he has co-operated with the local authorities in experimenting as to the best methods of improving the road surfaces through the proper admixture of such local materials as sands and clays, and the success of this work has been so marked in many of the counties that it has resulted in new work of this kind on a considerable scale being undertaken in a number of localities. A careful study of these experiments, together with similar experiments which have been tried in other States, shows conclusively that by such simple methods of using the cheap local materials good earth roads can be constructed at a cost of a few hundred dollars per mile, which roads will remain in good condition, under constant usage and with but little repairs, for several years.

In the middle and western counties, such as Wake, Durham, Guilford, Alamance, Cabarrus, Mecklenburg, Forsyth, Buncombe and a number of others, and in New Hanover county, in the eastern part of the State, the work has developed along the lines of the proper grading, relocating and macadamizing of the public roads. In this work there has been a gratifying improvement, both in the nature and extent of the work accomplished, and in the uniformity with which the people continue to support this extensive work in an increasing number of counties in the State as soon as they have had an opportunity to see and appreciate its value. A few years ago in almost any county in North Carolina a suggestion that roads be constructed such as would cost from $1,500 to $3,000 per mile would have received a decidedly unfavorable consideration; but so thoroughly is the value of good roads coming to be appreciated in the State that the voting of road taxes for the construction of such costly roads is done with increasing frequency every year.

The Clerk of the Survey, Mr. R. H. Sykes, has carefully collected all available *data* concerning the road work done in each of the counties of North Carolina, including the number of miles of public roads improved after different methods, the cost of this work, the extent to which convict labor has been employed, the cost of this labor as compared with hired labor, etc. For comparative purposes, he has also collected similar statistics for counties in all of the other Southern States; and these statistics indicate that in road-building, as in other lines of prosperity and progress, North Carolina ranks with the foremost of the Southern States.

MINERAL INVESTIGATIONS.

In the investigation of the mineral deposits of the State, Dr. Joseph Hyde Pratt, the Mineralogist of the Survey, has continued to collect *data* showing the extent and distribution of the different mineral deposits in each of the counties of the State, and the extent to which these deposits were being developed by mining operations. In this work he has been assisted during the summer months of both 1903 and 1904 by Mr. D. B. Sterrett. Three short papers have been prepared by Dr. Pratt, one on the mining operations in North Carolina during 1902, another on the mining operations in North Carolina during 1903, and the third on the tin deposits in the Carolinas, one of which is now in the hands of the Public Printer, and another is now ready for publication.

Many specimens of minerals and ores are constantly being received from various parties throughout the State for identification. In some instances the specimens received and determined have resulted in the development of mining properties of some value. No assays or analyses have been made of any of the ores or minerals, as there is no appropriation for this purpose; but the specimens have been determined mineralogically and information given as to their value if in quantity, and of the probability or possibility of their developing into commercial deposits.

Many mineral deposits have been examined by members of the Geological Survey for residents of the State, when they have been in the vicinity of the properties. The results of such examinations are always given to the owners of the properties before they are published in any form. The Survey has in many instances been the means of preventing citizens of the State and others from investing in mineral deposits of little or no value. This has been accomplished in two or three cases by a simple determination of the mineral, which showed that it was an entirely different material from what the intending purchaser supposed. In other cases the examination of the property has shown conclusively that it was not of any commercial value. Thus the work of the Survey in this respect has been instrumental in two ways in increasing the resources and revenue of the State: first, by calling attention to the mineral properties that are of value and worthy of investigation and development; and second, by preventing as far as possible the investment of moneys in mineral properties of little or no value.

Letters of inquiry are constantly being received from residents of the State and non-residents regarding the occurrence of various minerals in the State, their location, ownership and extent of deposits. Such inquiries are always answered as fully as possible, and the writer is referred to the owner of the property. Such correspondence has often led to the sale of mineral lands or the mineral products. The usefulness of the Geological Survey along this line of work cannot be definitely estimated, but it forms a considerable part of its work.

These investigations of the mineral and ore deposits have been extended in a preliminary way through nearly every county of the State; and as rapidly as topographic maps are being drawn and engraved by the Government and turned over to the State Geological Survey, the exact location of the various deposits is located on these maps. Furthermore, examinations have been made as to the nature and extent of the mineral deposits in each of these counties, so that at an early date Dr. Pratt will have completed the preparation of a report on the miscellaneous mineral wealth of the State and its development.

Meanwhile, the Geological Survey is keeping in the closest possible touch with all the mining interests of the State, and is doing everything possible looking to its development on a more intelligent basis; and while the value of our annual mineral production is not as great as that in some other States, yet it is steadily developing, and the annual value of these products has increased to the extent of more than a million dollars during the continuance of the present Geological Survey.

Individual statistics of the production of the various minerals have been collected each year and published as "The Mining Industry in North Carolina." Besides the actual statistics, these reports contain descriptions of mineral localities. Attention is directed to those that are of commercial importance, and there is given in every way possible accurate information regarding the development and value of the property.

BUILDING STONE INVESTIGATIONS.

The building stone resources of the State have been investigated with considerable care by Prof. George P. Merrill of the U. S. National Museum, assisted by Mr. F. B. Laney and Prof. T. L. Watson. This work was begun in May, 1903, and continued during the summer and early autumn months by Professor Merrill and Professor Watson, and from May, 1903, until the end of that year by Mr. Laney. During the winter of 1903-'04 and the early spring months of 1904 each of these gentlemen was engaged—Mr. Laney for the entire time and Professor Merrill and Professor Watson each for a part of his time—in the preparation of the report on the building and ornamental stones of North Carolina, which report is now ready for publication.

These investigations have indicated the beds of valuable building materials—especially the granites—to be greater in extent and variety than had at any time been anticipated, and one of the indirect results of the investigations has been the use of one of North Carolina's granites (from Mount Airy) in the superstructure of the new National Museum at Washington, a building which is to cost over three and a half million dollars.

The principal belt of granites examined was that extending from Mecklenburg county north and northwestward through Iredell, Cabarrus, Rowan, Davidson, Guilford, Alamance, and Caswell counties; but other outlying granite deposits to both the eastward and westward of this belt were also examined. To the eastward of this was one large area extending through portions of Wake, Franklin, Granville, and Vance counties, and other smaller areas in Wilson county to the east and Anson county to the southwest were carefully examined. In the more western part of the State especial attention was given to the granites at Mt. Airy and other somewhat isolated localities.

The brownstone and other sandstone formations were examined in the belt ranging from 1 to 15 miles in width, extending across portions of Anson, Richmond, Chatham, Orange, Durham, Wake, and Granville counties, which stones are being quarried at several places, more especially in the vicinity of Sanford. Especial attention was also given to the sandstones in Stokes county—in the narrow belt following the course of the Dan river 15 to 20 miles. An examination was also made of the marble and limestone deposits found in McDowell, Mitchell, and Cherokee counties; and of these, as in the case of sandstones, and especially the granites, specimens were collected and prepared for the State Museum, illustrating the character of the more important stone deposits.

GEOLOGY OF THE MOUNTAIN COUNTIES.

The general and economic geology of Western North Carolina has been examined with considerable care and the geological formations of that region have been mapped by Mr. Arthur Keith, assisted by Mr. H. S. Gale of the United States Geological Survey, under an arrangement of co-operation with the State Survey. This work has been continued during both 1903 and 1904, and a report embodying the results of the investigation of the entire mountain region will be prepared by Mr. Keith for publication by the State Survey at an early date.

During the several years preceding, topographic surveys of the mountain counties have been conducted with considerable care, and the elaborate topographic maps on a scale of two miles to the inch have been prepared for the use of the geologists. On the topographic maps the geologists are locating the rock formations, minerals, ore deposits, building stones, water-powers and other features. A number of these maps are now being prepared for publication and will be issued at an early date.

During 1903-'04 the greater part of this work was carried on in Macon, Swain, Jackson, Transylvania, Haywood, and Henderson counties. Other counties in which less time was spent are Clay, Buncombe, Madison, Yancey, and Mitchell. This work was the continuation of the systematic examination of the mountain section of the State. The prime objects of the work were to map the rock formations, to discover the different ways in which the rocks had been altered and tilted, and to examine and classify the mineral deposits of value.

In most of the counties surveyed the greater part of the surface is covered by a few formations of ancient crystalline rocks, such as granite, gneiss, and schist. A few narrow belts of slate and similar rocks were also mapped, the chief of these running through Swannanoa Gap and the upper French Broad Valley. These rocks were formed at many ages, from the very earliest to the latest, in the Appalachians, in a complex series. They are usually tilted at high angles and folded and twisted extensively. Their original forms have also been greatly changed in places by the growth of new minerals. The manner of these changes in position and appearance has received much study and has been deciphered in the main.

In the ancient gneisses are found the mineral deposits. These consist, in brief, of several groups:

(1) The mica veins of Mitchell, Yancey, Haywood, Jackson, and Macon counties.

(2) The deposits of precious stones in Mitchell, Yancey, Jackson, and Macon counties, comprising sapphire, emerald, aquamarine, amethyst, garnet, and minerals containing the rarer elements.

(3) Abrasive materials, such as corundum and garnet, in Yancey, Madison, Buncombe, Haywood, Jackson, Transylvania, Macon, and Clay counties.

(4) Talc deposits in Yancey, Madison, Buncombe, and Haywood.

(5) Kaolin deposits in Jackson, Macon, and Swain counties.

(6) Iron ores, chiefly magnetite, in Yancey, Buncombe, Madison, and Macon counties.

(7) Gold deposits, chiefly placers, in Henderson, Transylvania, and Jackson counties.

(8) Copper deposits in Jackson, Macon, and Swain counties.

(9) Nickel deposits in Madison, Buncombe, Jackson, and Macon counties.

In conducting the field work many difficulties have been encountered. Chief of these were the disturbed condition of the rocks, the heavy cover of timber and brush, the scarcity of out-crops, the thick cover of soil and decay of the rocks, and the difficulties of travel on account of the roughness of the roads and the mountainous character of the country. These, taken together, are so considerable that the time occupied in a given area of the mountains is three or four times as great as that required for the same amount of valley country.

Office work on this and other material previously obtained has resulted in the publication of the Asheville folio, comprising parts of Madison, Buncombe, and Haywood counties.

The Mt. Mitchell folio, which will speedily be issued, covers portions of Mitchell, Yancey, Madison, Buncombe, and McDowell counties.

The Nantahala and Mt. Guyot folios, which are ready for publication, cover portions of Cherokee, Graham, Clay, Macon, Swain, and Haywood counties.

The geological field work for the Cowee, Pisgah, Roan Mountain, and Morganton regions is practically completed. In these will be represented parts of Mitchell, Caldwell, Burke, McDowell, Henderson, Transylvania, Haywood, Jackson, Macon, and Swain counties. These counties embrace all of the mountain region which lies northwest of the Blue Ridge, and also the South Mountains, and the upper Catawba Valley. Those parts of the mountain section not yet completed are a small part of Henderson county, the topographic map of which is just finished, and Wilkes and Alleghany counties.

These small sections will be completed as soon as practicable. The folios, each of which covers nearly a thousand square miles, describe the relations of the particular district to the mountain section, the local geography and topography, the characteristics of the rock formations, the manner in which they have been altered, and the extent and value of the mineral deposits. Each formation and each mineral deposit is represented on the map by a separate color and the sections show the order of the strata and the positions which they now hold.

The work of examining the mineral ore deposits of portions of this mining region has been participated in by Dr. Pratt, Mr. Sterrett, Prof. Lewis, Mr. Laney and the State Geologist.

INVESTIGATIONS OF COPPER DEPOSITS.

The copper deposits of Ashe and Alleghany counties were examined by Mr. W. H. Weed in the summer of 1904. Among these deposits, the northernmost, the old Peach Bottom or Maxwell property, was as carefully investigated as was possible with the mine idle and badly caved in. This mine was first worked as a lead mine and subsequently for copper. The Gap Creek mine, a somewhat noted producer of gold-bearing copper ores, was also examined, but it has also been idle for many years. The machinery is still intact, and as the copper carries exceptionally high values in gold and silver, it offers favorable conditions for profitable development.

The famous Ore Knob deposit was also visited, but, like the others, is now idle and could be investigated on the surface only. In 1903 a contract was entered into by which the dump heaps of this property were leased to a company to use the Garretson process. A large amount of money was expended in refitting the old smelter buildings and putting up two furnaces, but no copper was made. This great property, though inactive for so many years, is capable of being profitably re-opened, as the ores are much like those at Ducktown, Tenn., and even under the old conditions copper was produced at a cost of 12½ cents a pound when treating three per cent. ore.

The Elk Knob property, in Ashe county, about two miles from the Tennessee line, was also visited, but here, as in the other cases, the examinations were limited to the surface. There are four openings on the mountain of this name, one of which was worked for some years. The ore was found to be an amphibolite schist, impregnated with chalcopyrite, pyrite and pyrrhotite. Further developments will be necessary before the value of the property can be determined.

The copper deposits in Granville and Person counties were investigated by Dr. J. H. Pratt and Prof. T. L. Watson; and their investigations are to be supplemented by a more careful survey by Mr. W. H. Weed as soon as the topographic maps of that region can be made. The region is one of decided promise, and will doubtless continue to yield more copper than any other in the State. At an early date it will be fully described and mapped, and this work will doubtless aid materially in the mining development of the region.

The recent explorations and mining work at the Blue Wing, the Yancey, the Tingen, the Holloway, and other mines in this district have demonstrated the value and continuity of these deposits, and indicate the importance that this copper belt may be expected to assume.

TOPOGRAPHIC SURVEYS.

The topographic survey of the State has been continued during both 1903 and 1904 by the topographers of the U. S. Geological Survey, under an arrangement of co-operation with the State Survey. The field surveys are being made on a scale of 1 mile to the inch, with such care and details as to show not only the general topographic features of the surface, but also the public roads, the more important houses, settlements and towns, the streams, water-powers, etc. The maps are being drawn and engraved as rapidly as the field work is completed, on a scale of 2 miles to the inch in Western and Middle North Carolina, and 1 mile to the inch in Eastern North Carolina. Of the total area of the State (52,250 square miles), about one-third, or 16,038 square miles, have been mapped.

During 1903, 664 square miles of area were carefully surveyed in portions of Caldwell, Mitchell, McDowell, Burke, Rutherford, Cleveland, and Catawba counties, at a total cost of $5,656—all of which was paid by the United States Geological Survey. In connection with this work 326 miles of level lines were run, 934 elevations were determined and 2,492 miles of public roads were measured.

In addition to this, a considerable area was surveyed in other portions of Buncombe, McDowell, Rutherford, Henderson, and Polk counties, and in addition to that surveys were made in Eastern North Carolina on the Trent river, Chocowinity and Winterville and other regions in Craven, Jones, Beaufort, Martin, and Pitt counties.

During 1904 the topographic surveys were extended over portions of Henderson, McDowell, Polk, and Rutherford counties in Western North Carolina, and Perquimans and Pasquotank counties in Eastern North Carolina; and surveys were begun and work was done preliminary to surveys in Mecklenburg, Cabarrus, Union, Gaston, and Lincoln counties.

This work has been done under the general supervision of Mr. H. M. Wilson of the United States Geological Survey, who has prepared for the State Survey a report in which he describes the methods followed in making such surveys and gives results obtained up to the present date.

The need of an accurate map of the State is constantly increasing. Many small-scale maps have been prepared in the past, but none of these were from actual surveys and none on a scale larger than 8 miles to the inch. The map which is now being prepared through this co-operative arrangement between the Government and State Surveys will be published in atlas sheets on a scale of 2 miles to the inch for Western and Middle North Carolina, and 1 mile to the inch for Eastern North Carolina, which will meet the needs that all have felt in this connection for many years past. When to these atlas sheets (those showing the ordinary topographic features) are added other sheets showing the geology and other economic features and brief descriptions of all these features, the result will be a compendium of reliable information published in convenient form and of incalculable value to the people.

The making of the topographic surveys and maps of North Carolina has been thus far carried on almost entirely at the expense of the Federal Government, but the progress made in this work is entirely too slow to meet the urgent demands of the industrial development in Middle and Western North Carolina; and in connection with the investigation of the soils and under-ground water supplies of the eastern counties there has grown up within the past few years in that portion of the State a demand for these surveys which is steadily increasing as their importance is appreciated. In this work North Carolina should follow the example of other States in making a larger appropriation for co-operative work between its State Geological Survey and the Federal Geological Survey, and thus largely increase the rate at which this work can be done.

SOIL EXAMINATIONS.

An examination of the soils of the State was begun in 1900 under an arrangement of co-operation between the United States Bureau of Soils, the North Carolina Department of Agriculture and the North Carolina Geological Survey. This work has been continued since that time as rapidly as the limited supply of suitable maps and the small appropriation would permit.

The soil survey is a preliminary classification of the lands. It does not attempt to place a valuation upon them, as that depends upon the topographic features, the amount of erosion, and the present and past history of the farms, etc. The total cost of the soil survey work to the State of North Carolina since 1900 has been $2,969.16, which amount was contributed by the State Department of Agriculture to the Bureau of Soils, for use in this work.

In making these examinations a soil survey party consists generally of two men, equipped with a compass, an odometer for measuring distances, a plane table to make or correct a base map, a soil auger with which they make frequent borings and take samples to a depth of three feet. They examine the soil carefully, noting the texture, whether sand, silt, or clay, the changes which take place at varying depths, the presence of gravel, the drainage conditions, and the character of the crops or native vegetation. The boundary between the different types of soils would be then traced out, the character of the soil, the vegetation, the crops, the climatic conditions, and the physiography, each being carefully noted as important in this work.

Separate samples of the soil and of the subsoil are sent in to the Bureau's laboratories from a number of borings in each of the soils, the number depending upon the extent and importance of the area or the agricultural problems presented therein. These samples are examined in the laboratories, a mechanical analysis is made to show the grade of material composing the soil, and such chemical work is done as experience may indicate will be of probable value in explaining the conditions encountered in the area.

The areas of the soils investigated in accordance with this plan in North Carolina are as follows:

	Square Miles.	*Acres.*
Alamance county	365	233,600
Asheville region	497	318,080
Cary region	63	40,320
Hickory region	988	632,320
Mount Mitchell region	497	318,080
Parmele region	236	151,040
Raleigh to New Bern, along railway lines	765	489,600
Saluda region	190	121,600
Statesville region	784	501,760
Craven county	897	574,080

The following areas are now being surveyed:

	Square Miles.	*Acres.*
Duplin county	830	531,200
Pasquotank county	250	160,000
Perquimans county	250	160,000
Totals	6712	4,331,680

The general benefits expected to follow from the soil survey work may be briefly described as follows:

Information is being rapidly secured to determine what soils are best adapted to the production of fruits, cotton, tobacco, corn, truck, and other staple crops. It is a matter of common remark by those who are familiar with the soils of the State, that in many sections crops are grown on soils wholly unsuited to them. The sooner the farmer knows definitely to what special crops his soils are adapted, the sooner the greater profits resulting from the proper adaptation of crops to soils will be realized.

The soil survey work is of considerable value in furnishing instruction as to the cultivation of different kinds of soils in various parts of the State. That sandy soils and heavy clay soils require different methods of cultivation has long been known, but the great importance of this has been most clearly brought out by the methods of the soil survey. In many sections of the State there are large bodies of productive clay soils which are not cultivated in such a manner as to realize their true value. The importance of special methods of cultivation and the growing of crops especially adapted to these clay soils is strongly emphasized in the reports of this work, now being published by the Government.

Another advantage of the work is the accurate basis which it furnishes for further experimentation. The mapping of the different soils in the State serves as a true guide for experimental work, whether with methods of cultivation, or of crop rotation, or with different manures and fertilizers; and the soil survey reports furnish accurate and valuable information to would-be settlers in the undeveloped parts of the State.

The need of topographic maps to enable the Bureau to continue its work over the remainder of the State: When the soil survey parties are equipped with accurate topographic maps, reproducing the prominent surface features of the county, more rapid and satisfactory progress can be made, and it is to be regretted that these maps are not available for the entire State. The cost and time, however, required to make these maps has rendered it necessary for the soil survey work to be carried on in some districts where topographic surveys have not yet been made. In those districts, where not even accurate county maps can be procured, the soil survey parties use a small plane table to map the roads and streams, thus securing a sufficiently accurate basis for the mapping of the soils.

WATER-POWER INVESTIGATIONS.

The investigation of the water-power resources has been in progress for several years, through an arrangement of co-operation between the North Carolina Geological Survey and the National Geological Survey. In order to determine the value of these water-powers at any given location on any stream, it has been necessary to determine not only the amount of fall and the volume of water in the stream at that point at a given time, but also to determine the variations in the volume of water at that point during different seasons of the year, and for a number of years. In order to accomplish this result, 16 river gauging stations were established and have been maintained during the past few years, as follows: One each on the Roanoke at Neals; on the Tar at Tarboro; on the Neuse at Selma; on the Cape Fear at Fayetteville and on the Yadkin at Salisbury; two each on the Catawba and the French Broad, and one each on the Pigeon, the Tuckaseegee, the Little Tennessee, the Hiwassee, the Toe and New rivers.

At each of the above stations daily measurements are made throughout the year of the height of water in the stream; and at somewhat irregular intervals, but approximately once each month, these stations are visited by an expert who measures the volume and the flow of the water in the stream at that date. These measurements are so timed as to be made at different stages of water in the stream, including the highest, the lowest and intermediate conditions. Such measurements are regarded as necessary for use in calculating the amount of water-power available in the stream at all seasons of the year.

In addition to the stream measurements just described, the course of each stream sufficiently large for water-power purposes in the State is being surveyed, and the sites for possible dams and storage reservoirs are being examined with a view of furnishing information as to the facilities for increasing the water-power by local storage.

FORESTRY INVESTIGATIONS.

To the forestry work of the Survey our Forester, Mr. W. W. Ashe, has given only a part of his time during the past two years; and this has been devoted mainly to the preparation of his reports on the forests and forest conditions in North Carolina. The co-operative work between the U. S. Bureau of Forestry and the State Geological Survey, covering the examination of the forests in the mountain counties of the State, has been highly beneficial in arousing public attention to the rapidity with which the southern mountain slopes are being denuded of their forests and the permanent injury resulting therefrom. The splendid report published by the National Government on this subject has done much to advertise the many advantages of Western North Carolina, and to increase the tourist travel to that region. It has also done much to arouse public opinion in favor of the establishment there of a permanent National Forest Reserve with a view to the protection of the forests, the streams and lands of the mountain slopes, and the streams which rise in these mountains and flow across adjacent States. The establishment of such a forest reserve cannot be much longer delayed.

For examination of the forests of the eastern counties, especially along the borders of the streams and in the great swamp areas of the State, co-operation between the U. S. Bureau of Forestry and the State Geological Survey has been arranged for, and this work will be pushed during the years 1905 and 1906.

FISH AND OYSTER INVESTIGATIONS.

The investigation of the fisheries and oyster beds of the State has been continued during the past two years on a basis of co-operation between the United States Bureau of Fisheries and the State Geological Survey. The work which has been carried on under such an arrangement during the two years preceding by Dr. Caswell Grave, has been continued during the past two years by Dr. Grave in the summer months, and by Mr. R. E. Coker, the Biologist of the State Geological Survey, throughout the entire period of the past two years. A report on the oyster industry by Dr. Grave is now ready for publication, and a report is now being prepared by Mr. Coker embodying the results of his experiments in the planting of new oyster beds, and the lessons which these experiments teach.

The results of the investigations into the life conditions existing in the waters of Pamlico Sound seem to indicate that the food supply for the oyster is sufficient to render possible its growth in practically all parts of the area investigated, which include fully one-third of the total area. The main purpose of the investigation now under way is to determine whether the bottom of this area, and to what extent the food supplies, bottom and water of the remainder of the Sound are favorable for oyster development. These investigations involve an examination into the food supplies suitable for the oyster, the spreading of oyster shells, and the planting of young oysters in areas from 100 to 300 feet square in many portions of Pamlico Sound, where at the present time no oysters are found. It also requires the re-examination of these areas at frequent intervals for the purpose of determining the rate of development of these planted oysters, of their lack of development in case the conditions prove unfavorable. In these investigations we have had the co-operation of the Shell-fish Commissioner, Mr. Webb. But as will be readily understood, these investigations entail a heavy expense on the part of the Geological Survey, and they should really be provided for by a special additional appropriation, in order that the work might be carried on more rapidly.

Mr. Coker has also investigated the terrapin industry of Eastern North Carolina, and a report will be prepared on this at an early date. Mr. Allen Taylor is now experimenting on the artificial propagation of the clam; and Mr. S. G. Worth, of the U. S. Bureau of Fisheries, is investigating the habits and life of the mullet with a view to its artificial propagation in North Carolina waters. If successful this work will be of great value to the people of that region. The artificial propagation of the striped bass will be begun in 1905, by the U. S. Bureau of Fisheries, in North Carolina; and this will add to the annual value of our fishery industry.

The result of the past investigations of North Carolina fisheries will be embodied in a report on the fish and fishery industries of the State by Dr. H. M. Smith of the U. S. Bureau of Fisheries. This report, which is now nearly ready for publication, will contain short illustrated descriptions of every species of fish known to inhabit North Carolina waters; and it will also contain descriptions and illustrations of various fishery industries. It will thus serve not only as a hand-book of information concerning the fishery industries of North Carolina, but it will also serve as a manual for the determining of the different species of fish that may be found in the waters of the State.

These fishery investigations have recently developed the fact that in connection with the shad industry this fish which in the spring season enters and ascends the rivers of the State, during the spawning season, is being largely caught at the entrances of these inlets and rivers before it is ready to spawn, and hence no eggs can be gathered for artificial propagation. This will seriously interfere with the perpetuation of the supply of this fish, and will rapidly destroy the shad fishing. Such a situation can only be remedied by suitable legislation, such as will open the channels for the passage of the shad into and through Pamlico to its head, so that when caught their eggs will be ripe and can be used for the artificial propagation at the government hatchery at Edenton.

STATE MINING EXHIBIT AT ST. LOUIS.

The State Mining Exhibit at the St. Louis Exposition has received a considerable part of the time and attention of the State Geologist and his assistants during the latter half of 1903 and all of the year 1904. The Survey has co-operated with the State Commissioner to the Exposition in the collection, installation and maintenance at the Exposition of a highly creditable mineral and mining exhibit. This exhibit was not as large nor as showy as those made there by many other States and countries having large appropriations to expend for this purpose; but it has received the general commendation of persons best qualified to judge of such matters, and the list of awards granted to it by the Exposition juries is surpassed by that of but few other States.

PERSONNEL OF THE GEOLOGICAL SURVEY.

The *personnel* of the Geological Survey during the years 1903-'04 included the following list, many of these persons giving but a small part of their time to the work of the survey and receiving but small compensation in proportion:

J. A. Holmes, State Geologist, has during 1904 spent the larger part of his time at St. Louis, Mo., in connection with the work of the Louisiana Purchase Exposition and the North Carolina Exhibit; but even during this year he has continued the correspondence of the Survey, the general supervision of its work and the preparation of its reports for publication. To these several duties he has given a large portion of his time. He has, however, been paid for this no regular salary, but only such compensation (averaging less than $90 per month) as was deemed a fair return for work accomplished, in accordance with the instructions of the Geological Board and with the approval of the Governor.

Joseph Hyde Pratt, the Mineralogist of the Survey, with headquarters at Chapel Hill, has continued the examination of the mineral and ore deposits of the State, has attended to much of the correspondence of the Survey, has investigated and reported on the mining developments in the State and is now preparing an elaborate report on the Miscellaneous Mineral Resources of the State.

W. W. Ashe, Forestry Expert, with headquarters at Raleigh, has been engaged mainly in the preparation of reports, embodying the results of his examinations of the forests and forest conditions in the State.

W. L. Spoon, Road Engineer, with headquarters at Burlington, has visited the several counties of the State at intervals, advising with the authorities as to the best road material, the most practical methods of road improvement, has laid off new roads and new locations for old roads; has attended and assisted in good roads conventions and otherwise aided the good roads movement.

F. B. Laney, with headquarters at Chapel Hill, from May, 1903, to April, 1904, was engaged in examining building stone resources and in the preparation of a report on the same. During the remainder of 1904 he has been at the St. Louis Exposition in charge of the North Carolina Mineral Exhibit.

George P. Merrill, United States National Museum, Washington, D. C., leading stone expert of the country, from May, 1903, to March, 1904, was engaged at intervals in examining North Carolina building stone and preparing a report on the same.

R. H. Sykes, Executive Clerk, Chapel Hill, has had charge of the clerical work of the Survey, attended good roads meetings, prepared and published good roads literature.

H. M. Wilson, United States Geological Survey, Washington, D. C., leading topographic expert of the country, during December, 1902, and January, 1903, prepared a report on the topographic surveys in North Carolina.

Thomas L. Watson, Professor, Blacksburg, Va., co-operated with Prof. Merrill and Mr. Laney in the examination of building stone deposits in North Carolina from June to October, 1903, and prepared report on the same.

R. E. Coker, Biologist of the Survey, Beaufort, N. C., examined oyster, fish, terrapin and clam industries and prepared reports on the same during 1903 and 1904.

Caswell Grave, Instructor, Johns Hopkins University, Baltimore, Md., examined oyster beds in Eastern North Carolina during portions of 1902, 1903 and 1904, and prepared a report on the same.

L. C. Glenn, Professor, Vanderbilt University, Nashville, Tenn., at intervals during 1900-1903, prepared lists of all publications relating to North Carolina geology and natural history. During the summer of 1904 he examined the mountain forests and rivers of Western North Carolina.

D. B. Sterrett, assistant in mineral investigations during the summer of 1903 and 1904.

B. S. Drane, assistant in charge of river measurements and water-power investigations throughout 1903 and 1904.

B. M. Hall, Water-power Engineer, Atlanta, Ga., during 1903 and the earlier months of 1904, prepared a report on the water-powers of North Carolina.

E. E. Howell, Washington, D. C., leading modeling expert of the United States, during September, 1902, January, 1903, prepared a model in relief of Western North Carolina and adjacent portions of the Southern Appalachian region.

A. S. Wheeler, Chapel Hill, did chemical work for the Survey during part of February, 1903.

J. V. Lewis, former Assistant Geologist on the North Carolina Geological Survey, Professor of Rutgers College, New Brunswick, N. J., at intervals during 1903-'04, aided in the preparation of a report on the corundum deposits of Western North Carolina—which deposits he had previously examined in the field.

George F. Kunz, New York, leading gem expert in the United States, during 1903 to April, 1904, prepared a report on the gems and precious stones of North Carolina.

George F. Atkinson, Professor, Cornell University, during the summer of 1903, continued the examination of the edible and poisonous fungi of Western North Carolina.

H. A. Wheeler, one of the leading clay experts of the country, aided in work on the clays during January and February, 1903.

Henri Walters, Draughtsman, assisted in office drawings during January, 1903.

R. G. Finney, Stenographer, was engaged one-fourth of the months of January to April, 1903.

J. G. Cotchett, served as Stenographer, January 1 to September 15, 1903.

Miss H. M. Berry, served as Stenographer, for one-third of the time, January to November, 1904.

Miss M. G. Davis, served as Stenographer, December, 1902, to December, 1903.

N. L. Shaw and James Day, janitors and office assistants, December, 1903, to November, 1904.

C. F. Massey, Salisbury, N. C., employed in collecting building stone samples for testing and exhibit purposes.

A. H. Baldwin, United States National Museum, Washington, D. C., during 1903, prepared drawings of North Carolina fish for illustrating the forthcoming report on the fishery interests of the State.

George M. Wood, Washington, D. C., assisted in editing publications of the Survey during 1903.

P. M. Pearsall served as Secretary to the Geological Board, 1900-1904.

REPORTS TO BE PUBLISHED.

Of the reports of the Geological Survey already published several are now out of print; of others the edition is nearly exhausted. Some half-dozen reports of varying lengths are now being prepared; and the following reports are now practically ready for the printer:

1. A report on the Corundum and basic magnesian rocks of Western North Carolina, about 350 printed pages.
2. A report on the Fish and Fisheries of North Carolina, about 400 pages.
3. A report on the Gems and Precious Stones of North Carolina, about 50 pages.
4. A report on the Building Stones of North Carolina, about 300 pages.
5. A report on the Water Supply and Water-powers of North Carolina, about 250 pages.
6. A report on the Miscellaneous Mineral Resources of North Carolina, about 300 pages.
7. A preliminary report on the Oyster Industry of North Carolina, about 75 pages.

BENEFITS RESULTING FROM THE WORK OF THE NORTH CAROLINA GEOLOGICAL SURVEY.

In concluding this administrative report of the investigations of the Geological Survey during the past two years, it may not be inappropriate to review briefly some of the more important benefits which have resulted from its recent work in the State:

(1) The Geological Survey is the one agency which the State maintains for the exploration, development and advertisement of its resources. During the first few years after the Survey was established, it was necessary that those connected with it should devote their entire time to making explorations of the mineral and ore deposits and the general economic geology of the State, and the preparation and publication of reports describing the same. Several such preliminary reports have been published and widely distributed through different parts of the United States and some of the foreign countries, and while the benefits from this work have only just begun, they have been

sufficient to demonstrate that the money expended for the support of the Survey by the State was a wise investment.

(2) Already this work has been instrumental in bringing into the State more than $5,000,000 in investments in mineral, timber and water-power developments, and it has directed the investment of capital on the part of our own citizens in similar investments on a scale almost as extensive. The outlook for large annual increases in these investments has never in the history of the State been so promising as at the present time.

(3) The Geological Survey has by timely advice, based on its investigations, prevented the expenditure by citizens of the State of several hundred thousand dollars in cases where this money, if expended, would certainly have been lost, and such failures would have prevented other legitimate expenditures.

(4) The distribution of reports of the Geological Survey through different parts of the United States and foreign countries, and also the extensive republication in journals and newspapers of extracts from these reports, is gradually attracting attention to North Carolina, and has already been instrumental in bringing to the State a number of desirable settlers—some of whom have undertaken mining operations, others have organized or co-operated in operating manufacturing enterprises, and still others have turned their attention to farming.

(5) The reports and maps descriptive of the State, which are now being prepared and published, and its resources will serve as a basis for mining and manufacturing developments for many years; and the mapping and examination of the soils which is being carried on jointly by the Geological Survey, the State Department of Agriculture and the United States Bureau of Soils, will serve as a basis for more intelligent and productive farming for an indefinite future.

(6) In connection with the oyster and fishery interests of the State, the work of the United States Fish Commission and the State Geological Survey co-operating will aid much in perpetuating and even improving the fishery conditions; and it is believed that the investigations now under way will indicate the plans through which the oyster and fishery interests of the State may be largely extended.

NOTE.—In paragraph (2) above the first two lines should read as follows: Already during the past five years this work has been instrumental in bringing into the State more than $5,000,000 in investments in mineral, timber and

(7) The investigations by the Survey of the forests and forest conditions in the mountain counties and the publication of reports setting forth the beauties and other attractions of that region, during the past several years have increased continuously the number of visitors to that region as well as the number of investors of capital there.

(8) But what is generally regarded as the most important work accomplished by the Geological Survey has been in connection with the awakening and guiding of the good-roads movement in the State. During the past year (1903) the amount of money actually expended in road-building in North Carolina was approximately $400,000; for 1902 the amount expended was $295,000, and for 1901 approximately $230,000. During the past four years the amount expended for this purpose in the State has been more than $1,000,000. During the ten years preceding approximately a million dollars more was expended in that direction. During this time practically seven hundred miles of permanent public roads have been constructed, and several hundred additional miles of public roads have been greatly improved.

Not only has this good-roads movement been in large measure created by the Geological Survey, but a large part of the work accomplished in the way of road-building and repair has been done under the advice of the State Geologist and his assistants. And it may be safely assumed that if the benefits of the work of the Geological Survey during the past ten years had been limited entirely to this work of road improvement the expenditure necessary for its maintenance would be more than justified.

EXPENDITURES OF THE GEOLOGICAL SURVEY.

Under the act creating the North Carolina Geological Survey, the expenditures cannot exceed the sum of ten thousand dollars for any one year; and all such expenditures are made by the State Geologist under the direction of the Geological Board. Each item of expenditure is covered by receipted vouchers and sub-vouchers. These are grouped together and deposited with the Governor, as nearly as practicable at the end of each month, and along with the reports of the State Geologist these are submitted to the Geological Board for examination and approval at its regular semi-annual meetings. After such

C. F. Massey, Special Assistant in Building Stone Investigation, 78.23 days, at $3 per day	$ 234.69
George F. Kunz, Gem Expert, 50 days, at $5 per day	250.00
A. H. Baldwin, Special Assistant in the Preparation of Illustrations for Fisheries Bulletin, 52 1-5 days, at $5 per day	261.00
B. M. Hall, Special Water-powers Assistant, 2 months, at $100 per month	200.00
L. C. Glenn, Assistant in Office Work, 41 days, at $2 per day	82.00
N. L. Shaw, Janitor for Office, 19 months, at $10 per month	190.00
James Day, Assistant in Office, 9 months, at $5 per month	45.00
L. B. Gallaher, Photographic Work, 3 1-4 days, at $2 per day	6.50
O. A. Ljungstedt, Special Assistant, making Geologic Maps and Figures for Illustrating Building Stone Report, 4 days, at $2 per day	8.00
L. F. Ward, services in making 12 Sandstone Cubes for exhibit at St. Louis Exposition, 7 days, at $3 per day	21.00
Total	$15,532.70

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NORTH CAROLINA GEOLOGICAL SURVEY

JOSEPH HYDE PRATT, State Geologist.

BIENNIAL REPORT

OF THE

STATE GEOLOGIST

1905-1906

RALEIGH
E. M. Uzzell & Co., State Printers and Binders
1907

NORTH CAROLINA GEOLOGICAL SURVEY

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GEOLOGICAL BOARD.

GOVERNOR R. B. GLENN, *ex officio Chairman*	Raleigh.
HENRY E. FRIES	Winston-Salem.
FRANK R. HEWITT	Asheville.
HUGH MACRAE	Wilmington.
FRANK WOOD	Edenton.

JOSEPH HYDE PRATT, State Geologist	Chapel Hill.

CONTENTS.

PAGE.

Introduction 7
Mineral and Geological Investigations 8
  Mineral Investigations 8
    Gold 9
    Copper 10
    Tin 11
    Mica 11
    Monazite 11
  Geological Investigations 13
    Coastal Plain Geology 13
    Mountain Region Geology 16
Black Sands Investigations 17
  Concentrating Plant 18
Examination of Mineral Specimens 19
Topographic and Traverse Mapping of the State 19
  Traverse Maps 21
Good Roads 21
Hydrography 30
  Artesian Water Supply 30
  Stream Measurements 31
  Mineral Waters 32
Forestry 33
  Southern Appalachian Forest Reserve 33
  Resolutions Relating to Forest Reserves 37
State Swamp Lands 39
  Report on Certain Swamp Lands 40
  Forestry Problems Along the Banks 47
Magnetic Survey 50
  Magnetic Observations on North Carolina Stations 51
  Earlier Observations at North Carolina Stations 51
Fishing Industries 52
Publications 54
Coöperative Work with Federal Surveys 55
Office Work 55

LETTER OF TRANSMITTAL.

Chapel Hill, N. C., January 1, 1907.

To His Excellency, Governor R. B. Glenn.

Sir:—I herewith submit the Biennial Report of the North Carolina Geological and Economic Survey for the fiscal years 1905 and 1906. It includes a brief outline of the work accomplished by the Survey, referring for more detailed information to the reports that have been published. Certain special reports, however, are given here in their entirety, as being the most practicable place to publish them. Suggestions have been made regarding further legislation in connection with the work of the Survey, and I beg to call your particular attention to these.

At the end of the report is a statement regarding the expenditures of the Survey, showing approximately the cost of each investigation taken up.

Yours obediently,

Joseph Hyde Pratt,

State Geologist.

BIENNIAL REPORT
OF THE
STATE GEOLOGIST

ON THE OPERATIONS OF THE NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY FOR THE TWO YEARS ENDING NOVEMBER 30, 1906.

BY JOSEPH HYDE PRATT, STATE GEOLOGIST.

INTRODUCTION.

The North Carolina Geological and Economic Survey was authorized by an act of the General Assembly of 1905, as recorded in Chapter 542 of the Public Laws of North Carolina, 1905. On account of the enormous amount of work that this Department is called upon to do, and the very varied investigations that it has made and is still carrying on, it is impossible to give in this report more than a brief outline of the work accomplished and refer to the published reports which give in detail the results of all these investigations.

The objects of this Survey, as stated in the act creating it, are to include:

1. "An examination of the mineral, forest, fish and other material resources of the State.

2. "Examination of the geological formations of the State, with reference to their economic products.

3. "An examination of the road-building materials and the best method of utilizing same.

4. "An examination and classification of the soils, the forests and other physical features of the State, with special reference to their bearing upon the occupation of the people.

5. "An examination of the streams and water-powers of the State, with special reference to the development for manufacturing enterprises and the preservation of the sources of these streams through the protection of the forests.

6. "The consideration of such other scientific and economic problems as in the judgment of the Geological Board shall be deemed of value to the people of the State.

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7. "The preparation of such reports, illustrations and maps as may be deemed necessary in placing the results of these investigations before the public.

8. "An examination of the water supplies of the State, with special reference to the sinking of deep or artesian wells.

9. "The State Geologist, with the approval of the Geological Board, is hereby authorized to arrange for and accept such aid and coöperation from the several United States Government Bureaus and other sources as may assist in completing the topographic surveys of the State and in carrying out other provisions of this chapter."

As is seen from the above, the objects of the Survey include practically everything related to natural resources in which the State is in any way interested. Some are at the present time of much more importance than others, and in arranging the work consideration has been given to the more important lines of work. Thus, special investigations have been made relating to the artesian water supply in eastern North Carolina; construction and maintenance of public roads throughout the whole State; to the condition of the fish and oyster industries; to the value of the State's supply of building stones; to the need and value to North Carolina of the establishment of the Appalachian Forest Reserve; and to the metallurgical treatment and utilization of the low-grade gold ores.

While the above have received the greater attention, other investigations have also been undertaken relating to the occurrence and commercial value of the copper ores, mica, tin and monazite; the value of the forest lands belonging to the State; the magnetic variations, etc. Certain investigations that had been begun and nearly completed by the former Survey have been finished, and the results in some instances have been published.

MINERAL AND GEOLOGICAL INVESTIGATIONS.

MINERAL INVESTIGATIONS.

In this connection the Survey has examined regarding the production of each mineral that has been mined or quarried in the State during each year, and these results have been published in a series of reports on the Mining Industry of the State during 1904 and 1905, known as Economic Papers Nos. 9 and 11. These Economic

Papers give not only the statistics of the actual production of these minerals, but also descriptions of new mineral localities, and calls particular attention to those that are apparently of economic importance. These statistics have now been collected for six years, and the past year has shown a decided increase in the value of the mineral products of the State.

The statistics are arranged so as to show the value and quantity of each mineral produced, and also the quantity and value of all the mineral products obtained from each county. There are certain minerals, as mica, monazite and zircon, for which North Carolina is especially noted, and she produces more of these than all the other States in the Union. The State's mineral products of greatest value are clay and building stones, and although these are being developed more and more each year, they are far from being produced as extensively as the quantity and quality of these products would warrant.

The field work that has been carried on during the past two years has covered a wide area and has included the investigation of many minerals and ores.

Gold.—The gold deposits, especially the low-grade ores, have been thoroughly investigated and the results are being prepared for publication as an Economic Paper on Further Investigations of the Gold Deposits of North Carolina. Therefore, only a short synopsis of this work, which has been done by Messrs. A. A. Steel, F. B. Laney and the State Geologist, is given here.

During the field seasons all of the working gold mines of the State, regarding which creditable reports could be obtained, have been examined; and also many new localities, especially those where the ore is of low grade but in large quantity. Certain concentrating machines have been examined, with special reference to their adaptability to the saprolitic rocks that carry a small amount of fine gold. One of these, known as the Modern Pulverizing and Concentrating Machine, has with modifications been operated successfully at a number of localities, as at the Shuford mine near Edith, Catawba County, and at the old Lafflin mine near Cox, Randolph County.

This investigation of the gold deposits of North Carolina has shown conclusively that one cause of failure of many of the gold mines has been the inefficiency of those placed in charge of the property. Most of the better gold mines in the State will contain low-grade ore, and a careful, economical and conservative management is absolutely essential to the successful operation of the mine. Also, it will be necessary to carry on the operations on a very large scale, so as to be able to treat a large tonnage of ore. In order to do this it is necessary before commencing mill operations to have blocked out a body of ore that will be equal to at least a two years' supply for the mill. Unfortunately, in many instances, there has been a very large expenditure of capital in installing a stamp mill, concentrating plant, or some other machinery, for treatment of the ore before there has been any large body of ore definitely blocked out. The result in most cases has been the closing down of the property from lack of capital to develop it.

Copper.—The copper deposits are being thoroughly investigated, and the field work on this should be completed early in 1907. The results of the investigation will be published in a bulletin on the Copper Deposits of the State. This work has included a thorough investigation of the Swain County copper deposits on Hazel Creek by Mr. F. B. Laney. In order to do this work satisfactorily it was necessary to make a detailed survey of about 75 square miles of territory, including all the Eagle Creek water-shed and the greater portion of the Hazel Creek water-shed. The whole area was traversed in detail and mapped on a scale of 5 inches to the mile by Mr. Charles N. Parker, of Asheville, N. C. The territory was also studied geologically, and the work has shown that the greater portion of the area is probably barren as regards ore deposits, and that the mineralized zone is only a narrow belt extending from near Siler's Bald southwestward to near the mouth of Eagle Creek. This zone is in proximity to an igneous dike, probably of diorite, which may be the source of the ore. Part of this work has been done in coöperation with the R. E. Wood and Montvale Lumber Company.

Investigations were begun on the copper deposits in Jackson County, but only the Cullowhee mine could be studied in any detail. A detailed study was made of this mine and the relation of the ore to the rocks, and work was begun on the general structure of the region. This work will undoubtedly be of practical value by throwing light on the relations of the ores to faulting, folding and jointing. This work will be continued during the coming summer.

The Gold Hill copper deposits in Rowan County and those near Cid, Davidson County, have been investigated by Messrs. Steel and

Laney. In these investigations maps were made of the underground workings and, as far as it is possible, a comprehensive idea was obtained regarding the occurrence and origin of these copper deposits, and the results should be of large practical value in the future development and mining of these deposits and others in the vicinity.

The copper deposits in Person and Granville counties have been studied to some extent by the State Geologist, and the work in this section will be completed early in the spring.

A preliminary reconnaissance has been made of the copper deposits in Ashe and Alleghany counties, and their investigation will be completed in the early summer of 1907.

Tin.—The tin deposits of Cleveland, Gaston and Lincoln counties have been further studied by Mr. F. B. Laney and the State Geologist, and it is believed that information of practical value will be derived when the data and material collected have been thoroughly studied.

Mica.—Investigations regarding the occurrence of mica and its associated minerals have been continued during the past two field seasons by Mr. Douglas B. Sterrett and the State Geologist. Field work was carried on in Ashe, Mitchell, Yancey, Watauga, Wilkes, Lincoln, Cleveland, Rutherford, Buncombe, Jackson, Macon, and Swain counties. Nearly all of the data have now been collected for the publication of a volume on Mica and the Pegmatites of Western North Carolina. This volume will include not only a thorough discussion of the occurrence, value, distribution and quantity of mica in North Carolina, but will also take up a detailed description of the other economic minerals that are found in these pegmatitic dikes, which will include the uranium ores, which are also radium ores; of columbite and samarskite, ores of tantalum; and gem minerals.

Monazite.—The monazite regions are being investigated principally as to the minerals of economic value, besides monazite that are contained in the sands and gravels. This work is being done in connection with the black sand investigation, which is referred to beyond. This work will undoubtedly result in demonstrating that other minerals, such as magnetite, garnet, zircon, etc., can be separated commercially from these sands, thus increasing their value to the producer.

The North Carolina Survey has coöperated with the Federal Survey in a special investigation of the mineral resources of an area known as the Balsam Forest Region, which includes parts of Haywood, Jackson, and Transylvania counties. Detailed topographic and geologic work has been done, and a special report is now being prepared on the general mineral resources of that area. The topographic and geologic map work will be used in the Cowee and Pisgah geologic folios of the Federal Survey that are now being prepared.

In all the above investigations on the minerals mentioned there has always been more or less information and data collected regarding the general mineral resources of the various sections in which the investigations were carried on, thus adding to our general knowledge of the mineral resources of the State. All this information will be brought together and a volume published on the General Mineral Resources of North Carolina. This will be a volume of about 500 pages, and will include a description of every mineral that has been found in North Carolina.

The investigation of the building and ornamental stones of the State has been completed and the report published as Bulletin 2. This work has received most favorable consideration and has already been of considerable value to the State. Through the advertising of the building stones, their production in the State has increased in the past few years nearly 100 per cent. The following letter recently received will indicate how this publication has been received and what is thought of its value:

> SALISBURY, N. C., December 14, 1906.
>
> MR. JOSEPH HYDE PRATT, Chapel Hill, N. C.
>
> DEAR MR. PRATT:—I do not know that I have ever told you how highly I value your recent publication on Building Stones in North Carolina, Bulletin No. 2. It is very complete indeed, and I have found it in matters with which I am acquainted to be thoroughly accurate. It should be worth a great many thousand dollars to this State in promoting the building-stone industry and giving reliable information to those seeking investment in that field.
>
> Yours very truly,
> (Signed) GEO. R. COLLINS.

The report on Corundum and the Peridotites of Western North Carolina, which also takes up chromite and other economic minerals associated with these rocks, has been published as Volume I. This publication has also been very favorably received, as is indicated by the many letters received and the general commendation of the press.

Bulletin 19 on the Tin Deposits of the Carolinas has also been published and has been the means of calling considerable attention to these deposits.

GEOLOGICAL INVESTIGATIONS.

During the investigations of the minerals and ores the general geology of the various regions was also studied, and the ultimate end of this work is the preparation of a geological map of the whole State, which will be made on a large enough scale so that all the geological formations can be shown in detail, which will permit of its being used advantageously by the miner, prospector and investigator.

Coastal Plain Geology.—During the fall of 1905 and summer and fall of 1906 the geology of the coastal plain region has been studied by Messrs. L. W. Stephenson, E. W. Berry, B. L. Miller, and J. E. Pogue, Jr., with special reference to strata that will contain artesian water. This work has been done in coöperation with the United States Geological Survey, and has been under the direct supervision of Mr. W. B. Clark of the Federal Survey and the State Geologist.

Mr. Stephenson and Mr. Pogue entered the field on June 13th. The larger coastal plain rivers of the State, including the Roanoke, Tar, Neuse, and Cape Fear, were traversed from or above the point where they leave the Piedmont rocks on the northwest to beyond the point where they widen out into tide-water estuaries. Tributaries of these streams, including Contentnea Creek, Northeast Cape Fear River, and Black River, were traversed along the important part of their course. The Great Pee Dee River of South Carolina was traversed across the coastal plain to Georgetown, and its subtributary, the Lumber River, in North Carolina, was traversed in part. Limited investigations were conducted in the interstream areas. The strata exposed along these streams, and in the interstream areas visited, were studied, and the main facts relating to the structure, lithologic character, etc., of the mesozoic coastal plain formations, and their relations to the overlying younger tertiary and pleistocene formations were learned. Fossils, including plants and marine invertebrates, were collected from the cretaceous deposits. The plants are being studied by Mr. E. W. Berry of Johns Hopkins University, Baltimore, and the marine invertebrates by Dr. T. W. Stanton of the United States Geological Survey, Washington, D. C. Collections of eocene and miocene invertebrates were also made, and are now being studied by Dr. B. L. Miller of Bryn Mawr College, Bryn Mawr, Pennsylvania.

In addition to these strictly geological investigations, hasty artesian water investigations were conducted in the vicinity of Greenville, Pitt County; Washington, Beaufort County, and in Hyde County; and influential citizens who were interested in the subject of artesian wells in these several communities, and well-drillers, and contractors, were interviewed.

In southeastern North Carolina, and especially in the vicinity of Wilmington, New Hanover County, hydrographic investigations begun in the fall of 1905 were continued at various times during the summer as opportunity offered.

In the vicinity of Wilmington and at a few other localities sets of well-samples, aggregating about one dozen in all, were obtained.

The results of these investigations have been to add much to the knowledge of the structure and character of the deposits of a region which, up to the present, has been but imperfectly known.

On the practical side the investigations have resulted in a better understanding of the nature of the water-bearing strata, the depths at which they occur, and roughly the quality and quantity of the water which may be expected in the different parts of the region. However, since the water-bearing strata are deeply buried and are often many miles removed from their catchment area, that is, the area in which they come to the surface, it is apparent that a complete understanding of the practical side of the subject cannot be attained to until a large number of carefully kept well-records and set of well-samples have been obtained and carefully studied and compared, and there has been made a large number of water analyses.

Mr. E. W. Berry remained in the field from June 13th to July 23d, paying special attention to the Potomac formations and to the presence or absence of plant fossils in these deposits. Sections were run from the edge of the Piedmont plateau region to the coast along the Roanoke, Neuse, and Cape Fear Rivers in North Carolina, and along the Great Pee Dee River in South Carolina. By far the most instructive section is the more or less well-known one along the Cape Fear River, and since features are brought out in this section which are more or less obscured or incomplete in other parts of the region a very brief statement of the conditions may not be amiss. Along this river the tripartite division of the later mesozoic deposits is strikingly brought out. Lying upon the uneven edges of the Piedmont crystalline or triassic rocks are the undifferentiated arkosic argillaceous, often indurated, sands of the Older Potomac, lying almost horizontally, and well exposed both above and below Fayetteville, North Carolina, and also at many other points in the State along the border of the Piedmont. Fossil plants, which form so prominent a feature in the Potomac of Maryland and Virginia, were not observed, although small basins with well-preserved plants would probably reward a more careful and extended search than it was possible to give during the past summer. Lying with a marked unconformity upon the Older Potomac is a great thickness of laminated lignitic sands and clays which are transitional in character and carry leaves having Raritan and Tuscaloosa affinities. Lithologically similar to the Magothy and Eutaw formations, and carrying marine fossils in their more or less glauconitic upper layers, it is possible that these beds represent more than one horizon during which deposition was continuous, as no discordance was observed. This is further borne out by their thickness, indicated by an outcrop at right angles to the strike of nearly fifty miles. Determinable plants were collected from two localities along the Cape Fear River and from two localities along the Neuse River, and these are being studied. It is believed that more extended search would disclose other localities carrying identifiable leaves. Above the transitional cretaceous are the widespread greensands with local calcareous layers and carrying characteristic upper cretaceous fossils. Both the Older Potomac and the transitional cretaceous develop artesian water horizons which, it is believed, will prove of great economic value with further study.

Dr. B. L. Miller was in the field from June 13th to July 3d, during which time a study was made of the sections exposed along the Roanoke River between Weldon and Plymouth, along the Neuse River from Slocum Creek to within about eight miles of Goldsboro, along the Trent River from New Bern to within a few miles of Pollocksville, and along the Cape Fear River between Wilmington and Fayetteville. In this work careful notes were taken of all good exposures and collections of eocene, miocene and pliocene fossils were made at twenty-two different localities. The collections, while not exhaustive, are representative. Small collections of tertiary fossils from fifteen other localities were made by L. W. Stephenson. All of the specimens have been carefully prepared for determination and progress is being made in this work. The results already obtained indicate striking faunal differences between the eocene and miocene of North Carolina and the States lying to the north. The discontinuous areas occupied by the tertiary within North Carolina also form a great contrast to the continuous strata of Virginia, Maryland, and New Jersey.

The absence of topographic maps and the short time spent in the field prevented much work from being done on the quaternary deposits. Fossil plants were found at one point, while some of the marine shells collected in the eastern portions of the State may prove to be of quaternary age. The great variation in thickness of the pleistocene strata is very striking, varying from 0 to 50 feet.

Messrs. Stephenson and Berry devoted their time particularly to a study of the older coastal plain formations, including the jurassic (?) and cretaceous. Dr. Miller, on the other hand, devoted his time to a study of the tertiary and quaternary formations.

By the end of the coming field season sufficient data will have been obtained for three separate volumes: one on the Underground Water Supply of Eastern North Carolina; another on the Cretaceous Formations of the Coastal Plain Region, and a third on the Tertiary Formations of the Coastal Plain Region. Of these, the one on the Underground Water Supply will take up chemical analyses of various underground waters and also certain of the river waters, and will give a record of the artesian wells of the coastal plain region, together with general information regarding the water-bearing strata and, as far as possible, their position in various sections of the State. The work will be continued during the coming field season in coöperation with the United States Geological Survey.

The banks off the coast of North Carolina have been studied for a number of years by Professor Collier Cobb, and additional data are now being collected by him regarding the movements of the dunes along the coast. The results of this investigation will be published as a bulletin on the Sand-Dunes and Reefs of North Carolina.

Another line of investigation work to be carried out in connection with these banks is in regard to the preservation of the small areas of forests that still remain upon them, and also as to the possibility of reforestation of other portions of the banks. A full description of this work is given under the head of Forestry.

Mountain Region Geology.—Besides the general study of the geological regions in which minerals and ores have been investigated, detailed geological work has been carried on in western North Carolina by Messrs. Arthur Keith, D. B. Sterrett, and H. S. Gale of the United States Geological Survey, in coöperation with the North Carolina Geological Survey. Certain definite areas covered by topographic sheets were studied, and the results will be published as geological folios by the United States Geological Survey. The following geological folios have already been published: The Asheville, covering parts of Buncombe, Madison, McDowell, Yancey, and Henderson counties; Mt. Mitchell, covering portions of Mitchell, Yancey, Madison, Buncombe, and McDowell counties; and the Cranberry, covering portions of Ashe, Watauga, Mitchell, and McDowell counties. The field work on the Morganton, Saluda, and Pisgah folios has been completed, and these will probably be ready for distribution during 1907.

BLACK SAND INVESTIGATIONS.

There is now being undertaken by the United States Geological Survey, in coöperation with the North Carolina Geological and Economic Survey, a comprehensive investigation of the useful minerals contained in placer deposits, especially those containing what is known as the black sands, and in the sands along the Atlantic seacoast. Many of these gravel deposits and sands contain, besides the precious metals gold, silver, and platinum, such minerals as magnetite, chromite, ilmenite, monazite, garnet, chrysolite, zircon, quartz, etc., which, by means of the various machines that will be used, can be separated not only from the precious metals, but from each other. Some of these minerals have a decided commercial value, and as they can be separated from each other so as to give an almost pure product of each, they can be obtained in a marketable condition. There is more or less demand for them, depending, however, upon the quantity of each that can be obtained.

It may be demonstrated that it will be possible to clean quartz sands such as occur along our sea-shores so as to obtain a sand sufficiently pure to be used in the manufacture of glass. As there are many extensive beds of these sands and gravels in North Carolina, these investigations will be of very great value to the State, and already, as a result of the preliminary work that has been done, arrangements are now being made for the installation by private individuals of a plant to be located near Morganton, Burke County, which will be erected under the supervision of the North Carolina Geological and Economic Survey, and will also be operated under their direction.

The work includes the investigation of the placer sands and gravels from all the Southern Appalachian States.

Concentrating Plant.—The installation of the concentrating plant at Chapel Hill to carry on the black sand investigations is being pushed as rapidly as possible, although there have been various serious delays on account of non-delivery of freight. This plant, which will be used in testing methods for separating the various minerals in the black sands and other placer deposits, will also be used to test the pulp obtained by crushing ores from deep mines. The larger portion of the equipment has been loaned by the various manufacturers for this work. The equipment is partly as follows:

One Wifley concentrating table, loaned by the Mines and Smelter Supply Co. of Denver, Col.;

One Wetherill magnetic separator, type E, of full size, loaned by the Wetherill Magnetic Separator Co. of New York;

One Blake-Morscher electric ore separator, loaned by the Blake Mining and Milling Co., Denver, Col.;

One 2 K. W., 125 volts, 1,400 R. P. M. compound wound No. 1 type S generator and attachments, loaned by the Westinghouse Electric and Manufacturing Company;

One 5-H. P. standard horizontal gasoline engine No. 57,371, complete with all fitting and fixtures, loaned by Fairbanks, Morse & Co. of Chicago, Ill.

One Stanwood gravity muller;

One ore crusher;

A rock crusher and ore pulverizer;

Screens, classifiers, and elevators;

A 125-cell storage battery, built and loaned by the Electric Storage Battery Co. of Philadelphia.

The concentrating plant is in charge of Mr. T. W. Johnston, but under the direct supervision of the State Geologist.

In connection with the concentrating plant there will be a well-equipped and complete assay laboratory, which will permit of the determination of the actual values of gold, silver, platinum, and other metals that the ores or sands may contain. The apparatus has been partly loaned and partly purchased of the F. W. Braun Company of Los Angeles, California, and Messrs. Eimer & Amend of New York City. It is supplied with crucible and cupelling furnaces, with complete blow-pipe apparatus; and Cary hydrocarbon burner; necessary crucibles, cupels, scorifiers, fluxes, etc.; and all necessary chemicals and apparatus for making simple mineralogical determinations. The weighing apparatus includes very fine pulp and button balances.

Tubs for panning small samples of sand have been conveniently arranged in the mineralogical laboratory. They are supplied with stop-cock connections, so that the tailings, when required, can be drawn off or saved, as desired.

EXAMINATION OF MINERAL SPECIMENS.

Specimens of minerals are constantly being received at the Survey office for examination. In many cases requests are made for chemical analyses or assays of these. As there is no regular appropriation for such analytical work, it is impossible for the Survey office to have quantitative analyses or assays made of these ores and minerals without charging the sender the cost of same. Any mineral specimens sent in will be examined and identified without any cost to the one sending the sample. Information will also be given as to the probable value of the sample, and whether, in the opinion of this office, an assay or further analytical work would be desirable. During the past two years over three hundred samples have been received, examined and reported on. Similar examinations of mineral specimens are also made by the State Geologist and his assistants while engaged in field work, and thus the actual number of specimens examined for various people throughout the State will be double the number given above.

There are at the present time about 800 individuals and companies interested in the development of mines and mineral lands in the State.

TOPOGRAPHIC AND TRAVERSE MAPPING OF THE STATE.

All of the topographic work that has been done in North Carolina has been by the Federal Survey in coöperation with the State Board of Agriculture and the North Carolina Geological and Economic Survey. While considerable progress has been made in the topographic mapping of the State, there still remains a very large area to be mapped, and as these maps are of infinite value to the State, a more liberal coöperation on the part of the State would be most beneficial to her interests. The value of these maps is not confined to any community or to any one class of people. The agriculturist and landowners will be benefited by having at hand topographic maps of their section of the country, inasmuch as they can determine the relation of all farms and houses to the slopes and water drainage of the region; bottom lands and hill lands, with their differing soils and adaptability to different crops, can be distinguished; and they are the basis of our soil maps, of which every farmer in North Carolina is in need. All timber areas will be shown on the maps; also roads, railroads, bridges, forests, rivers, streams, etc., and thus all who use country roads and who desire the construction of good roads would be benefited by having these maps. Any county that is taking up the question of road improvement and is intending to spend large sums in the construction of graded and macadam roads will find the topographic map of inestimable value, in that it not only shows the existing roads, but also shows the topography and drainage basins, and thus better grades for new roads can be readily determined and worked out. There are undoubtedly instances in North Carolina where sufficient money has been wasted in the location and construction of a poorly chosen road which would pay the cost for the preparation of a topographic map of the whole county.

All those who are interested in obtaining water supplies for towns and cities will be very materially assisted in this work by the use of these topographic maps, for the drainage basins of all the streams and rivers are accurately mapped, and an idea can be obtained of the flow of the water. This will reduce very materially the expense of preliminary surveys for the location of public water supplies and it will also lessen the chances of serious mistakes being made in the location of public water-works. In the same way these maps are of value to owners of mills and factories, to various institutions that have to rely upon their own water supplies, and to sanitary hydraulic and civil engineers.

For attracting attention to water-powers and aiding in the development of same, topographic maps have been, and will continue to be, strong factors. They show the fall per mile of the streams and rivers and give some idea of the volume of water.

Their educational value should not be overlooked, and every school in the State should have at least a full map of its own county and, preferably, a full set of the topographic maps of the whole State.

Not only will individuals be benefited by these topographic maps, but the Legislature of the State will obtain reliable information from them upon questions that may affect legislation; our courts will be able to use them for guidance in certain cases; the State Board of Health will find them of very great assistance in connection with sanitary tests; and the State Board of Agriculture will need them in their work. Thus their use and value is multiple, and covers wide interests throughout the whole State. For these reasons it is most desirable that the topographic mapping of the State be pushed forward just as rapidly as possible. The State, by coöperating with the Federal Survey, can secure more rapid progress in this work and by appropriating from its own treasury a certain amount, the Federal Survey will appropriate an equal amount to carry on particular topographic work in the State, this allotment to be in excess of the regular allotment that would naturally be used in the regular topographic mapping of North Carolina. I would, therefore, most earnestly recommend that the Legislature appropriate from the treasury of the State a sum of not less than $10,000 per year until this most important work is completed, provided that an equal amount is expended each year by the Federal Survey for this work in the State.

Traverse Maps.—In making the topographic maps the first work to do would be the preparation of a traverse map showing location of streams, roads, prominent peaks and showing levels at approximately every six miles, but would not, of course, show any contour lines. Such maps could be finished much faster and cover a greater territory than the topographic maps, and would be of very great value in the soil, geological and mineralogical work. Such maps would also be prepared under the coöperative system with the Federal Survey. During the past year the North Carolina Survey had an accurate traverse map made of about 75 square miles of area in Swain County in connection with the investigation of the copper ores.

GOOD ROADS.

There continues to be very great interest throughout the State in the construction of good roads; and while as yet only a small proportion of the counties has taken up the construction of macadam roads, still each year sees one or two new counties added to those that are constructing graded macadam roads. The value of good roads to a community, county and State is being emphasized more and more each year, and their practical and commercial value are now realized by most of the people. One striking fact is to be noted in connection with the construction of macadam roads throughout the State, and that is that no county which has once begun the construction of macadam roads has stopped this work. In each case the county has appropriated more and more until the whole county is traversed by good roads.

In order to facilitate the construction of good roads throughout the State, the State could not make better use of a portion of its income than by expending a certain amount of this in State aid to counties in the construction of macadam or other permanent roads. The benefit to be derived from the construction of good roads in the various counties composing the State is not only of great value to the individual county, but also to the State as a whole. They will mean a large increase in the revenue of the State due to the increase in the value of real estate; they will mean a large increase in population due to immigration, which will not take place with poor roads, and we can undoubtedly trace the lack of immigration in North Carolina largely to the existence of poor roads throughout the State. They will mean better schools, and good roads and good schools are the best advertisement of a State's prosperity.

It is a significant fact, and one worthy of consideration, that no State which has once inaugurated State aid in the construction, supervision and investigation of its public highways has ever given up this work, but has made it permanent, and in most cases has widened its scope and increased its appropriations. The following States are now aiding in the construction and maintenance of their public highways: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Virginia, Illinois, Michigan, Iowa, Colorado, Utah, California, and Washington. Thus far, Maryland and Virginia are the only two Southern States that are aiding their counties and towns in the construction of public roads.

When it is considered that there are approximately 49,763 miles of public roads of all kinds throughout the State, of which only about 1,350 miles are improved roads, surfaced either with stone, gravel or sand-clay mixtures, the need of State aid in the construction of good roads becomes very apparent. There is given in the following table the mileage of public roads in the various counties, together with the expenditures in 1904, both in money and labor, in the maintenance and construction of public roads. This table has been taken from a report of the Office of Public Roads, Circular No. 45, of the United States Department of Agriculture. The State Geologist assisted to some extent in revising and collecting certain of the statistics used in this table:

MILEAGE AND EXPENDITURES IN 1904.

County.	Miles of Public Roads.				Expenditures in Money and Labor.						Total Amount of Property and Labor Tax.
					Property Tax.		Labor Tax.				
	Total of all Public Roads.	Surfaced with Sand-clay Mixtures.[1]	Surfaced with Gravel.[1]	Surfaced with Stone.[1]	Road Levy—Rate Per $100.	Amount of Tax.[2]	Number of Men Subject to Tax.[3]	Number of Days' Labor Required Per Annum of Each Individual.	Value of One Day's Labor.	Value of Labor Tax.	
Alamance	540	----	----	10	$0.166	$12,996.47	3,085	3	$0.75	$6,941.25	$19,937.72
Alexander	500	----	----	----	------	----------	1,500	6	1.00	9,000.00	9,000.00
Alleghany	260	----	----	----	------	----------	1,100	8	.75	6,600.00	6,600.00
Anson	500	----	15	10	------	[4]6,516.30	500	6	.75	2,250.00	8,766.30
Ashe	600	----	----	----	.10	2,900.00	1,000	8	.75	6,000.00	8,900.00
Beaufort	350	----	4	----	------	----------	3,500	6	.75	15,750.00	15,750.00
Bertie	700	----	----	----	------	----------	2,500	6	1.00	15,000.00	15,000.00
Bladen	180	----	----	----	------	----------	2,000	6	1.00	12,000.00	12,000.00
Brunswick	300	----	----	----	------	----------	800	4	1.00	3,200.00	3,200.00
Buncombe	700	----	----	35	.15	20,000.00	1,400	4	1.00	5,600.00	25,600.00
Burke	383	----	2	2	.05	5,000.00	1,643	6	1.00	9,858.00	14,858.00
Cabarrus	332	----	20	12	.25	16,064.06	1,500	4	.75	4,500.00	20,564.06
Caldwell	1,200	----	----	----	------	----------	2,500	6	.75	11,250.00	11,250.00
Camden	200	----	----	----	------	----------	800	6	.75	3,600.00	3,600.00
Carteret	[5]150	----	----	----	------	----------	500	3	1.00	1,500.00	1,500.00
Caswell	500	----	----	----	------	----------	1,250	6	.75	5,625.00	5,625.00
Catawba	400	----	----	----	------	----------	3,000	6	1.00	18,000.00	18,000.00
Chatham	400	----	----	----	.10	6,000.00	3,000	4	.75	9,000.00	15,000.00
Cherokee	400	----	----	----	.10	3,500.00	2,000	6	1.00	12,000.00	15,500.00
Chowan	150	----	----	----	.25	3,600.00	800	6	1.00	4,800.00	8,400.00
Clay	150	----	----	----	.20	1,600.00	800	6	.75	3,600.00	5,200.00
Cleveland	650	----	----	----	------	----------	4,000	6	1.00	24,000.00	24,000.00
Columbus	400	----	----	----	.10	6,439.00	3,395	6	1.00	20,370.00	26,809.00
Craven	250	2	----	1	------	----------	150	6	.75	675.00	675.00
Cumberland	200	45	----	----	------	5,000.00	--------	--------	-----	----------	5,000.00
Currituck	140	----	50	----	------	----------	1,000	6	.75	4,500.00	4,500.00
Dare	1,000	----	----	----	------	----------	500	5	1.00	2,500.00	2,500.00
Davidson	100	----	----	----	.15	3,635.62	--------	--------	-----	----------	3,635.62
Davie	350	----	----	----	------	----------	1,700	6	.75	7,650.00	7,650.00
Duplin	800	----	----	----	------	----------	2,000	6	.75	9,000.00	9,000.00
Durham	550	----	----	45	.15	22,378.16	1,000	4	.75	3,000.00	25,378.16
Edgecombe	650	2	----	----	.15	11,665.00	--------	--------	-----	----------	11,665.00
Forsyth	1,000	----	----	8	.25	35,000.00	--------	--------	-----	----------	35,000.00
Franklin	550	----	40	----	.25	3,000.00	450	6	.75	2,025.00	5,025.00
Gaston	300	----	----	19	.25	21,000.00	4,200	2	.75	6,300.00	27,300.00
Gates	250	----	----	----	------	----------	1,400	6	1.00	8,400.00	8,400.00
Graham	200	----	----	----	.40	3,600.00	600	6	.75	2,700.00	6,300.00
Granville	650	----	15	2	.16	6,701.46	3,000	4	.75	9,000.00	15,701.46
Greene	400	----	50	----	------	----------	--------	--------	-----	----------	----------
Guilford	700	100	----	30	.123	[6]45,000.00	2,000	4	.80	6,400.00	51,400.00
Halifax	700	----	----	----	.12	8,000.00	--------	--------	.75	----------	8,000.00
Harnett	800	----	----	----	------	----------	3,500	6	.75	15,750.00	15,750.00
Haywood	150	----	10	5	.30	14,000.00	2,000	6	.60	7,200.00	21,200.00
Henderson	500	----	----	----	.10	400.00	1,750	6	.75	7,875.00	8,275.00
Hertford	[4]500	----	----	----	------	----------	792	6	1.00	4,752.00	4,752.00
Hyde	225	----	----	----	------	----------	925	6	1.00	5,550.00	5,550.00
Iredell	300	----	2	6	.15	12,000.00	--------	--------	-----	----------	12,000.00
Jackson	340	----	----	----	.15	5,751.75	1,788	4	.85	6,079.20	11,830.95
Johnston	800	100	----	----	.25	7,000.00	900	6	.75	4,050.00	11,050.00

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[1] Where figures are not given in these columns, no mileage has been reported.

[2] Where figures are not given in this column, no cash road levy was made.

[3] Where figures are not given in this column, no labor tax was levied, and convict labor was used for road work.

[4] Of this amount, $6,058.30 was realized from the sale of bonds.

[5] Includes 4 miles surfaced with shells.

[6] Of this amount, $35,000 was realized from the sale of bonds.

MILEAGE AND EXPENDITURES IN 1904—*Continued.*

County.	Miles of Public Roads.				Expenditures in Money and Labor.						Total Amount of Property and Labor Tax.
					Property Tax.		Labor Tax.				
	Total of all Public Roads.	Surfaced with Sand-clay Mixture.[1]	Surfaced with Gravel.[1]	Surfaced with Stone.[1]	Road Levy—Rate Per $100.	Amount of Tax.[2]	Number of Men Subject to Tax.[3]	Number of Days' Labor Required Per Annum of Each Individual.	Value of One Day's Labor.	Value of Labor Tax.	
Jones	400	----	----	----	$----	$---------	750	6	$ .75	$ 3,375.00	$ 3,375.00
Lenoir	500	9	----	----	.133	[5]9,320.00	--------	--------	.60	----------	9,320.00
Lincoln	450	----	----	----	.15	4,414.30	708	6	.75	3,186.00	7,600.30
McDowell	150	----	----	----	------	1,200.00	1,100	6	1.00	6,600.00	7,800.00
Macon	750	----	----	----	.30	6,000.00	1,500	6	.75	6,750.00	12,750.00
Madison	300	----	----	----	.05	2,000.00	2,000	8	.75	12,000.00	14,000.00
Martin	400	----	----	----	------	----------	1,800	6	.75	8,100.00	8,100.00
Mecklenburg	850	----	3	144	.35	85,422.73	3,800	4	1.00	15,200.00	100,622.73
Mitchell	700	----	2	----	.14	1,800.00	2,100	6	1.50	18,900.00	20,700.00
Montgomery	500	----	----	----	------	----------	2,000	6	.75	9,000.00	9,000.00
Moore	700	----	17	----	.24	1,800.00	2,000	6	.75	9,000.00	10,800.00
Nash	700	----	----	----	.25	2,038.92	4,500	6	.75	20,250.00	22,288.92
New Hanover	104	----	81	23	.40	[6]22,017.27	600	5	.40	1,200.00	6,125.30
Northampton	600	----	----	----	.20	13,659.00	1,950	3	1.00	5,850.00	19,509.00
Onslow	588	----	----	----	------	----------	2,119	6	1.00	12,714.00	12,714.00
Orange	200	----	----	----	.15	6,500.00	1,200	4	.75	3,600.00	10,100.00
Pamlico	180	----	----	----	------	----------	1,400	6	.50	4,200.00	4,200.00
Pasquotank	250	----	----	----	.10	2,391.48	1,500	4	1.00	6,000.00	8,391.48
Pender	1,300	----	----	----	------	----------	2,000	6	.75	9,000.00	9,000.00
Perquimans	325	----	----	----	------	----------	1,300	6	1.00	7,800.00	7,800.00
Person	600	100	----	----	.15	5,000.00	400	4	.75	1,200.00	6,200.00
Pitt	2,000	----	----	----	------	4,000.00	2,000	2	.75	3,000.00	7,000.00
Polk	200	----	----	----	.15	1,600.00	400	4	.50	800.00	2,400.00
Randolph	500	----	----	----	.083	5,331.52	6,200	6	.75	27,900.00	33,231.52
Richmond	200	----	3	----	------	----------	1,750	6	.75	7,875.00	7,875.00
Robeson	1,500	35	----	----	.75	30,000.00	--------	--------	.75	----------	30,000.00
Rockingham	700	----	----	2	.08	12,000.00	2,500	3	1.00	7,500.00	19,500.00
Rowan	300	----	2	26	.25	26,507.00	5,000	4	1.00	20,000.00	46,507.00
Rutherford	900	----	----	----	------	[7]500.00	1,200	6	1.00	7,200.00	7,700.00
Sampson	500	----	----	----	------	----------	3,600	6	1.00	21,600.00	21,600.00
Scotland	240	15	----	----	.15	4,500.00	750	4	.80	2,400.00	6,900.00
Stanly	800	----	----	----	.083	3,300.00	2,000	4	.75	6,000.00	9,300.00
Stokes	500	----	----	----	------	----------	2,500	6	.75	11,250.00	11,250.00
Surry	500	----	----	----	------	200.00	3,000	6	.75	13,500.00	13,700.00
Swain	300	----	----	----	------	----------	1,200	10	1.00	12,000.00	12,000.00
Transylvania	200	----	----	----	------	----------	1,200	10	.75	9,000.00	9,000.00
Tyrrell	136	----	----	----	------	----------	400	6	1.00	2,400.00	2,400.00
Union	1,000	----	44	----	.20	11,260.00	3,000	6	1.00	18,000.00	29,260.00
Vance	200	30	----	----	------	----------	400	2	.75	600.00	600.00
Wake	1,560	----	27	18	.15	[8]41,539.43	4,150	6	.75	18,675.00	60,214.43
Warren	400	----	25	----	.25	10,500.00	1,750	4	.75	5,250.00	15,750.00
Washington	200	----	----	----	------	----------	1,000	5	1.00	5,000.00	5,000.00
Watauga	200	----	----	----	------	----------	2,000	6	.65	7,800.00	7,800.00
Wayne	1,000	----	----	----	------	5,000.00	2,500	6	.75	11,250.00	16,250.00
Wilkes	1,500	----	----	----	------	----------	3,318	6	.75	14,931.00	14,931.00
Wilson	530	----	10	1	.15	14,000.00	--------	--------	.50	----------	14,000.00
Yadkin	500	----	----	----	------	----------	2,000	6	.75	9,000.00	9,000.00
Yancey	300	----	----	----	.10	1,831.31	1,000	6	.60	3,600.00	5,431.31
Total	49,763	438	422	399	------	624,380.78	161,773	--------	------	734,306.45	1,358,687.23

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[1] Where figures are not given in these columns, no mileage has been reported.

[2] Where figures are not given in this column, no cash road levy was made.

[3] Where figures are not given in this column, no labor tax was levied, and convict labor was used for road work.

[4] Includes 1 mile surfaced with shells.

[5] Includes amount received from labor tax of 40 cents on 3,300 persons.

[6] Of this amount, $17,091.97 was realized from the sale of bonds.

[7] This amount was used for bridges.

[8] Of this amount, $18,000 was realized from the sale of bonds.

Since the figures were obtained for this table there have been approximately 100 miles more of good roads constructed throughout the State.

It is the opinion of the State Geologist that in order to obtain the most satisfactory expenditure of labor and money in the repair and construction of the roads throughout North Carolina there should be some State supervision of its public roads. This could be done through a Highway Commission, who would have in its employ road engineers. There is undoubtedly sufficient money and labor expended each year by the various counties to thoroughly repair the present public roads, if this was judiciously expended under the supervision of one who has been trained in the construction of public roads. If all this money and labor could have been expended according to plans drawn up by the engineers of a Highway Commission, the roads would be made in a uniform manner and the money would have been expended so as to give the most practical results. When the State is so vitally interested in its roads and they mean so much to the prosperity of the State, it is only right that the State should interest itself in the construction of its roads. We have a State Board of Education who have general supervision of the schools throughout the State, and why should we not have a Highway Commission, who would have general supervision of the construction and repair of roads throughout the State?

The construction of a macadam or other improved surfaced road will mean—

1. That the market value of the real estate situated on or near the macadam road will be enhanced in value, and in many instances properties which could not be sold, even at a low figure, have found a market when they were connected with the neighboring town or city by means of a macadam road.

2. That rural free delivery will be extended as good roads are constructed, and is practically dependent upon good roads, for, with the construction of good roads there will be an increase in population and of the earning capacity of the adjacent farms, which will mean a greater amount of mail matter to be delivered. This is emphasized in the report of Postmaster-General Cortelyou, who said: "The requirement precedent to the establishment of rural delivery is to be a possible patronage of 100 families on a standard route of 24

miles; that the road be kept in good condition, unobstructed by gates, and with all streams fordable at all seasons of the year."

3. That farmers will be able to take advantage of market fluctuations in buying and selling.

4. That the farmer, fruit-grower, and others will be able to economize time and force in transportation between country and market.

5. That the wear and tear on horses, harness and vehicles will be reduced.

6. That better educational facilities will be possible in the rural districts, for it will not be necessary to have as many school districts and so many divisions of the school funds. The districts can be consolidated, thus permitting larger and better schools, insuring better teaching and more enthusiasm on the part of both pupil and teacher.

7. That tourists, capitalists, investors, and others visiting any section of the State will be much more favorably impressed with the financial possibilities of manufacturing enterprises or the commercial value of any farm or timber land by driving to them over good roads. If these same places have to be visited over poor roads, they will lose more than half their value in the sight of the prospective investor, as his thoughts have been so entirely taken up with the bad road over which he has been compelled to travel.

The Geological Survey is attempting, as far as possible, to give assistance in regard to the location of roads and the methods of construction of same in the various counties. The members of the Survey have been ready to meet with committees and deliver addresses in the counties regarding the value of public roads, best methods of constructing same and on the question of issuing bonds by counties. The Survey has also been ready to assist in the construction of the first mile of macadam road in any county by furnishing an engineer to give instruction and superintendence in the work. The State Geologist would most earnestly recommend that the present Legislature give serious consideration to the question of State aid for the constructing of public roads throughout the counties. This work is one of the most important that can be done by the State, and at least $100,000 annually could be spent most advantageously by the State in coöperation with the various counties. The amount that the State would appropriate for this purpose would be allotted proportionately to each county. Any county desiring to avail itself of this amount would be required to appropriate from its own treasury a like amount also, to be used in the construction of public roads within the county. The counties would be obliged to signify their acceptance of the State appropriation within a given time after the allotments were made and at the end of this time the amount appropriated to the counties not accepting the allotment would be reapportioned to the other counties. Thus, it would undoubtedly be the case that for a number of years there would be a number of counties that would not appropriate anything, and, therefore, the other counties who are fully alive to the value of macadam roads would be able to obtain a larger allotment from the State; but in every instance the county would be obliged to appropriate an amount from its treasury equal to whatever amount it would receive from the State appropriation.

In order to stimulate public opinion regarding good roads and to discuss various questions relating to this question, a series of Good Roads Circulars have been published from time to time by the North Carolina Geological and Economic Survey in coöperation with the North Carolina Good Roads Association. Forty-one of these circulars have now been published, of which the following is a copy of Circular No. 40:

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY.

GOOD ROADS CIRCULAR No. 40.

BY JOSEPH HYDE PRATT,

State Geologist and Secretary of the North Carolina Good Roads Association.

PUBLIC ROADS AND IMMIGRATION.

The State of North Carolina is at the present time extremely interested in the subject of immigration and, through its several departments, is making considerable effort to bring certain classes of European immigrants into the State. Many inducements have been circulated abroad for those seeking desirable and permanent homes, such as its excellent climate, which should be attractive to many from the southern part of Europe; its thousands of acres of fertile land that can be obtained very cheaply and on very reasonable terms; the large demand for labor which assures their easily obtaining employment in the neighborhood of their homes the year round and at good wages, this demand for labor including farmers, household servants, miners, mechanics and the most skilled workmen.

It is not the desire of the State to simply obtain an influx of labor, but to obtain an influx of home-seekers to become citizens of the State and at the same time furnish the kind of labor that is needed. We desire the better class of home-seekers, and these will want and demand school facilities for their children and good roads to connect them with town and railroad. The class of European immigrants that are desired in North Carolina have been accustomed in their own country to excellent roads, and it is natural and to be expected that a section of country that is traversed by good roads connecting the various farming districts with markets and providing easy means of intercourse between different neighborhoods will be more attractive than those districts in which the roads are poor and at some times of the year almost impassable.

We not only want European immigrants: we want to attract Americans from other sections of the United States to the South to invest in our farm lands, our water-powers and to build up manufacturing industries. Good roads are of vital importance to these classes of men. A man examining a farm district with the intention of investing in a farm will be more favorably impressed with the district if he can be driven to his destination over a good road so that his entire attention can be given to the farm lands that he is passing. On the other hand, if the road is poor, as so many of our North Carolina roads are at the present time, so that his attention is constantly being called to the road by reason of holes, ruts, stones and the general inconvenience of the road over which he is obliged to go, he has little thought for the beauties of the country or the value of the farming land, and his chief desire is to get back to the city and railroad. There is no doubt but hundreds and even thousands of good farms in North Carolina remain wholly or partially uncultivated and unproductive on account of the very poor condition of the roads connecting them with town and market.

If the railroads consider it necessary to improve their road-beds and their rolling-stock in order to build up a certain section of the country and spend large sums advertising the railroad facilities of the section in their attempts to induce labor and capital to locate there, how much more important that the counties and towns should improve their public roads, making them as far as possible macadam roads, and thus offer the strongest inducements for capital and labor to invest in their districts.

There is a certain class of immigrants that would probably pay little or no attention to the roads in the districts where they might settle; but is this the class of immigrants that North Carolina desires to have located within her borders? We can say emphatically, no. But we do desire those immigrants who will want and demand good roads, who will take a pride in keeping these roads, who will become public-spirited men, and instead of making the roads dumping grounds for waste materials of all kinds, clogging the ditches with trash, stones, brush, etc., will take pride in keeping the roads where they pass their farms clean, the grass and weeds cut, and remove waste material instead of dumping it into the roads.

The counties that are attracting the most capital and labor are those in which the roads are in the best condition. These counties will continue to derive the most benefit from any movements that are made for bringing immigrants into North Carolina. Good county roads indicate a prosperous county, and this is well illustrated in North Carolina where the richer, more progressive and more liberal counties are those which have spent a great deal of money in building good and permanent public roads.

It is a substantiated fact that no State in the Union is so attractive to every class seeking new homes and new investments as North Carolina. Most of these will select their locations on good roads. Some will be deterred from investing on account of the poor roads in the sections that they had expected to settle.

Many do not want to settle in our cities, towns or even villages, but want to be out on farms five or ten miles from the city or town, and want to be connected with the city by good roads. If good roads are so important to those coming into North Carolina, whether they be capitalists, health, pleasure, or home-seekers, or laborers, how much more important should good roads be to those already settled in North Carolina.

CHAPEL HILL, N. C., June 25, 1906.

The construction of improved roads in eastern North Carolina is complicated by the lack of material for macadam, and in many cases, of gravel, for making gravel roads. One solution of this problem is the construction of sand-clay or burnt-clay roads, which is possible in many sections of eastern North Carolina. The construction of sand-clay roads in North Carolina has passed the experimental stage, and it has been proved that they are well adapted for light traffic, and even under heavy traffic they have proved satisfactory to a great extent. There are certain sand-clay roads in the South Atlantic States over which heavy loads of cotton and other farm products are hauled throughout the year with but little real damage to the road. There are many sections of North Carolina where the construction of a sand-clay is, perhaps, the cheapest solution of the problem of road improvement for that particular section. Considerable care must be exercised in the construction of a sand-clay road, and in order to encourage the construction of this class of roads, the Office of Public Roads of the United States Department of Agriculture has issued Bulletin No. 27 on the Construction of Sand-clay Roads, by W. L. Spoon, who is one of the road experts of the Office of Public Roads, and also acts as road engineer of the North Carolina Geological and Economic Survey. Mr. Spoon has, during the past two years, superintended the construction of sand-clay roads in the vicinity of Kenansville, Duplin County.

Another form of road that may be used to advantage in certain localities is the burnt-clay road. Methods for the construction of this kind of road are also given in Bulletin No. 27, referred to above.

HYDROGRAPHY.

Artesian Water Supply.—As the study of the artesian water supply in eastern North Carolina is very closely related to the geological investigations of the coastal plain region, the work done along this line has practically been given under Coastal Plain Geology. While we are not yet in a position to give accurate information regarding the water-bearing strata in North Carolina, yet the information that has been obtained is of very great value in working out the problem of artesian water supply for this section of the State. With another year's field work, data will undoubtedly be obtained that will be of very material assistance in determining locations of drilling artesian wells. It is of very great assistance to have accurate records kept of all the wells that are being bored in North Carolina, and the State Geologist would appreciate it if all those who are boring wells, or contemplating doing so, would notify him, so that arrangements can be made for saving records from these wells which can be studied by the geologists in charge of this work. The greater number of well-records that can be obtained, the quicker more definite information can be given regarding the water-bearing strata, and it would undoubtedly be of considerable advantage to many of the counties in eastern North Carolina as well as to the State as a whole, if the counties would coöperate with the Geological Survey in boring a certain number of wells at points to be determined by the Survey and under the general direction of the Survey.

Stream Measurement.—Stream-gauging stations are maintained by the Hydrographic Branch of the United States Geological Survey, in coöperation with the North Carolina Geological and Economic Survey. At the present time there are thirteen of these stations at the following places: Bryson City, Davidson River, Horseshoe, Judson, Madison, Morganton, Murphy, North Wilkesboro, Pink Bed, Ranger, Salisbury, and Sittom. It is expected that the number of stations will be considerably increased during 1907, so as to include some in the central part of the State. At the present time the North Carolina Survey is paying the expenses of seven of these river observers. There is now in preparation an Appendix to Bulletin No. 8 on the Water-powers of North Carolina, which will give, up to January 1, 1907, all data that has been collected relating to gauge readings at the various stations since 1898, and also all discharge measurements that have been made and recorded. This publication should be a valuable addition of Bulletin 8 and be of considerable service to those interested in the development of water-powers throughout North Carolina.

In order to preserve our water-powers, it is absolutely essential that the forests on the mountain slopes in which these streams have their source should be protected, and this has been attempted through the efforts made relating to the creating of the Appalachian Forest Reserve, a discussion of which is taken up under the head Forestry.

Mineral Waters.—Some years ago an investigation was started relating to the mineral waters of North Carolina. Chemical analyses were made of the waters from many of the springs, and it is hoped that the additional data required to complete the manuscript can be collected and brought together during the coming year, so that this volume can be sent to the printer. There is a considerable demand for such a report, and it is believed that there is an opportunity of building up an industry of considerable importance to the State in the sale of mineral waters. There is at the present time a small amount of spring water that is being put on the market. Most of this that is bottled and sold is used for medicinal purposes, and there is very litle that is marketed which could be called a purely table water. Spring water is being used more and more for table use and North Carolina has springs of large flow whose water is pure and, if once introduced on the market, would undoubtedly find wide favor as table water. There are now fourteen springs from which, from time to time, the water has been bottled and shipped. They are as follows:

Alkalithia Spring, Alkalithia Springs, Alexander County.
Ashley Bromine and Arsenic Springs, Ashe County.
Barium Rock Springs, Barium Springs, Iredell County.
Buckhorn Lithia Springs, Bullock, Granville County.
Lemmon Spring, Lemmon Spring Station, Moore County.
Jackson Spring, Jackson, Moore County.
Haywood White Sulphur Spring, Waynesville, Haywood County.
Mida Spring, near Charlotte, Mecklenburg County.
Panacea Spring, near Littleton, Halifax County.
Parks Mineral Spring, Caswell County.
Red Spring, Red Springs, Robeson County.
Seven Springs, near Goldsboro, Wayne County.
Thompson Bromine-Arsenic Springs, Crumpler, Ashe County.
Vade Mecum Springs, Stokes County.

Many of the springs have hotels run in conjunction with them, which will accommodate many thousand people. In many instances it is the fact of the presence of the springs that makes the hotels possible and profitable.

FORESTRY.

Perhaps the most important work in forestry that has been undertaken during the past two years has been in relation to the establishment of the Appalachian Forest Reserve in the Southern Appalachians. Numerous newspaper and magazine articles have been written and published by different members of the Geological Survey staff setting forth the great value and need of such a forest reserve to North Carolina. The following article by the State Geologist takes up these questions in detail:

THE SOUTHERN APPALACHIAN FOREST RESERVE.*

BY JOSEPH HYDE PRATT.

The forest wealth of North Carolina, Tennessee, Georgia, and South Carolina makes the establishment of a Southern Appalachian Forest Reserve of very great interest to these States; but as these forests affect industries throughout all of the Southern States, and thus affect the industries of the entire country, the establishment of this Forest Reserve is a matter not only of State but also of National interest and concern. One hundred years ago there was little or no attention given in this country to the method or means by which its forests were cut away; that is, whether they were cut for lumber or ruthlessly destroyed in the clearing of land for agricultural purposes. There was no thought paid to the prevention of forest fires because they were harmful to the forests themselves; and no thought whatever was given to the influence that forests exert on the flow of streams and rivers. At that time there seemed to be a superabundance of lumber for all purposes, the wasteful destruction of which could not then be felt. Forest fires were not considered particularly harmful as long as they did not come too near the habitations of men. The streams and rivers always contained plenty of water and for a quarter of a century not enough land was cleared of forests to demonstrate the effect their removal had upon the water supply.

At the beginning of the 20th century, however, there has been a decided change in the views and ideas regarding the value to a country of its forest resources. Thus, our leading statesmen and citizens now realize and appreciate not only the commercial value of the perpetuation of the forests, but also the vast influence that these forests exert in the preservation of the water supply of the country. This is especially noticeable in mountainous and hilly sections. When these are covered with abundant forests, the decay of the fallen leaves form a loam which prevents the water from running off the surface too rapidly and washing away the soil or cutting deep gorges or ravines in the slopes of the hills. These forest-covered mountains are extremely valuable because of the effect they have upon water supply and water-powers.

By the removal of the forests there is no longer a protection for the soil on the slopes of the mountains and hills, except that produced artificially in the form of ditches, etc. There is no longer a layer or bed of leaves to act as an absorbent for the water and a preventive to its evaporation, and it runs off for the most part as fast as it falls, causing high freshets and floods and periods of extreme low water; causing the streams and rivers to be higher at times of floods, but very much lower the greater part of the time than they were before the removal of these forests. This is well illustrated at the present time in many parts of eastern United States where many of the rivers are not navigable to the extent that they formerly were.

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*Printed in the Journal of the Elisha Mitchell Scientific Society and distributed at a meeting held in Charlotte March 3, 1906.

To keep many of these open for navigation is now a constant expense to the National Government. While a great deal of damage and expense has already been caused in this way, there will be a still greater harm done if the remaining forests are not protected. It is not only the navigation of the streams and rivers that is hurt by the removal of the forests, but also the water supply for our cities and towns. Many of our largest cities are already beginning to find some difficulty in storing a sufficient supply of water for their use.

This preservation of the forests means also the maintenance of the water-powers, which, if reduced or destroyed, will seriously injure many of our manufacturing interests.

These defects in the water supply are not due to lack of rain, but to the removal of the natural agencies that nature has provided for the storing of this water. Again, these defects are not due to any considerable extent to the clearing of land for farming purposes, for the farmer must of necessity protect the soil from being washed away, and the only loss to the water supply that he would cause would be the greater evaporation to which it would be exposed. They are, however, due to the wasteful and destructive removal of the forests by the lumber companies, who leave large tracts of land stript in some cases of every vestige of a tree.

The present method of cutting timber and the subsequent forest fires is causing a scarcity of lumber, especially of the hardwoods, and there are now but few sections in this country where virgin forests of this character are to be found. This total destruction of a forest in lumbering is not necessary, but is a wasteful destruction of property, and a forest-covered area which should be a constant source of revenue, becomes in the end waste land, and in many cases an impoverished, barren tract.

This scarcity of hardwoods can be remedied by the application of practical forestry which would be adopted in any forest reserve established in the Southern Appalachian mountains and is now being practiced in the forest reserves of the western part of this country. There is little or no doubt but that the forests of the Southern Appalachian mountains can, by systematic and conservative measures, be made to yield profitable returns to the State and country. The forests of North Carolina and Tennessee are, and have been for many years, one of the chief resources of revenue to the people of these States, and their preservation and perpetuation means a constant source of revenue to these States.

Thus the two main and vital reasons for forest reserves are, first, the protection of the water supply of our streams and rivers; and second, the protection of our supplies of lumber, especially the hardwoods.

The region that is to comprise the proposed Appalachian Forest Reserve lies for the most part in western North Carolina and eastern Tennessee, with smaller areas in southwestern Virginia, northeastern Georgia, and northwestern South Carolina. The slopes of the mountains in this region are the sources of many large rivers, as the Tennessee, the Savannah, the Broad, and the Catawba. The water-power and navigation of these rivers are seriously affected by the removal of the forests in the mountainous districts, as is also the water supply for the towns and cities in the vicinity of the mountains and of these rivers. This southern section of the United States has not been subjected to glacial action as the Northern States have, and there are, therefore, no glacial drifts to act as storage reservoirs for water. Thus, in the removal of the forests we are practically removing all the natural resources for storing water.

In speaking of forest reserves and particularly of the proposed Southern Appalachian Reserve, President Roosevelt in his address at Raleigh, N. C., October 20, 1905, pointed out how vital the preservation of the forests is to the welfare of every country, and that the upper altitudes of the forested mountains are most valuable to the Nation as a whole, not only on account of their commercial value as supplies of lumber, but especially because of their effects upon the water supply. He further said: "Neither State nor Nation can afford to turn these mountains over to the unrestrained greed of those who would exploit them at the expense of the future. We cannot afford to wait longer before assuming control, in the interest of the public, of these forests; for if we do wait, the vested interests of private parties in them may become so strongly intrenched that it may be a most expensive task to oust them. If the Eastern States are wise, then from the Bay of Fundy to the Gulf we will see, within the next few years, a policy set on foot similar to that so fortunately carried out in the high Sierras of the West by the National Government. All the higher Appalachians should be reserved, either by the States or by the Nation. I much prefer that they should be put under National control, but it is a mere truism to say that they will not be reserved by the States or by the Nation unless you people of the South show a strong interest therein."

North Carolina, which would give the largest area to the Appalachian Forest Reserve, is unequalled in its variety of hardwoods and conifers by that of any other State or Territory.* Throughout the whole area of the State the great variety of soils and climate has brought together trees from all parts of Eastern America, so that twenty-four kinds of oaks are to be found in the State, which is three more than occur in any State to the north of this one, and two more than are to be found in any State to the south; of the nine kinds of hickories known to occur in the United States, eight have been found in North Carolina; here are all six maples of the Eastern United States; all the lindens; all six of the American magnolias; three of the birches; eight pines out of eleven; both species of hemlock and balsam-fir; three elms out of five; six arborescent species of plum and cherry; and three of pyrus (apple).

The bleak and exposed mountain summits bear forests of trees which there find their southern limit, but extend northward through northern New York and New England to Canada. Such trees are the black spruce (the balsam), striped and spiked maples, mountain sumac, which is really an apple, balsam-fir, and aspen—all, unless sheltered by other trees or by the slopes of the mountain above them, rugged and dwarfed from the cold and constant wind to which they are exposed.

The commercial forest trees are on the slopes of the mountains and in the ravines and valleys. Some of these trees have wide distribution to the north of North Carolina or to the south of it, or in both directions, and some of them are restricted in their distribution to North Carolina or to the region around the southern Appalachian Mountains.

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*Publication of the North Carolina Geological Survey on Forests of North Carolina. Bulletin No. 6.

The mossy cup, yellow and shingle oaks, white linden and big shag-bark hickory, prominent trees of the Central States, extend as far to the southeast as central North Carolina; while trees of the north, like hemlock, sugar or hard maple, northern red-oak, cherry, birch, and white pine, and of the northeast, like the pignut hickory, chestnut, northern pitch-pine, and balsam, enter more or less largely into the composition of the forests of the western part of the State.

Many trees of wide distribution, and among them some of the most valuable, extend from this State in all directions, the white, post, black, scarlet, and Spanish oaks, the red and white maples, the white, brown heart, and shag-bark hickories, short-leaf pine, yellow poplar, red cedar, black cherry, and black walnut. The cypress, water and willow oaks, downy poplar, swamp white-oak (Q. Michauxii, Nutt.), southern elm, and planer trees are trees having a great range to the south and southwest. A few trees are found only in this State, or extend but a short distance beyond its boundaries, the yellow-wood, the large-leafed umbrella tree, the Carolina hemlock, and the clammy locust, the last being entirely confined to this State.

Altogether, 153 kinds of woody plants, which form a simple upright stem and attain arborescent proportions, grow naturally within the State; and of these over seventy are trees of the first size, and fifty-seven are trees of great economic value. Fourteen of these are known to attain a height of over 100 feet, three of them a height of over 140 feet; sixteen of them reach diameters of five feet or over, and five reach diameters of seven feet or over.

The areas of the other States included in the proposed Forest Reserve also contain a large variety of trees, and thus this whole region contains the greatest variety of hardwoods to be found anywhere on the American Continent, for it is here that there is an intermingling of the sylva of the North and South. Here trees that are common to New England are found in close proximity to those that are common to the more Southern States. Here is the largest area of virgin forests to be found in the Southern Appalachian region. Here are trees from five to ten feet in diameter which often tower to a height of 140 feet. The destruction of such a forest would be an almost irreparable loss, for once destroyed it would take generations for its restoration, with a great probability of failure; and then again the chances are that it would not be attempted.

These areas of timber are being rapidly acquired by those whose one object is to make the most profit possible out of them at the present time, with no thought for the future. Many of the older countries, as Germany and England, have suffered to such an extent by the destruction of their forests that they, especially Germany, have begun already to take measures to preserve their forests and to make them such that they will be a constant source of lumber, and Germany has shown that by her system these forest reserves become self-supporting. England has become so depleted of her timber that she is obliged to import the greater part of her lumber.

The only remedy for the protection and preservation of our forests is for the National Government to obtain possession of them and to care for them by the application of scientific methods.

Such a forest reserve under the management of trained forest experts will demonstrate how these forests can be perpetuated and at the same time be made to pay. Such an example will have an influence on the several States and individuals by encouraging them to practice forestry and to use those lands for growing timber that are more suited for this purpose than for farming industries. It will be an object-lesson and a laboratory for those studying or interested in forestry.

The acquirement of this land by the National Government for a forest reserve will not be setting a precedent, for "nearly 50,000,000 of acres of forest-covered lands have been set aside (in the Western States) as National Forest Reserves and parks for the purposes of perpetuating a timber supply in the Western States and Territories and for preserving forever the sources of their more important streams." Thus what is now proposed is not new either in principle or practice. There are a number of reasons that can be given why this should be a National Forest Reserve. First, the problems and dangers that it is intended to meet are National; second, this tract of land lies in several States and the streams that rise in them flow through many States and it would be difficult, even if possible, for these States to control and operate such a reserve successfully; third, these States are not so situated financially that they could even make the attempt to carry out this plan. Thus if the forest reserve, such as is contemplated, is established, it must be done by the National Government. The several States have conferred upon Congress the necessary authority to acquire land within their respective borders. These lands can at the present time be purchased at a very reasonable price; but they are increasing in value from year to year. While there are these fifty millions of acres in National Forest Reserves and Parks in the West, there is not a single National Forest Reserve in the East. (There are a few State Reserves).

The withdrawal of this large amount of land and putting it into the hands of the Government will not prevent the development of its other resources (mineral and agricultural) for these can be developed as fast as capital desires, but under the judicial guidance of the Government, and it is possible for large industries to become established in them.

Besides being a forest reservation, this tract of land will also be a large National Park, though this is a secondary consideration. It will be a National Park that will contain scenery of rare natural beauty and the highest mountains east of the Rocky Mountains, which are covered with trees and shrubs to their summits. The healthfulness of this region is already known throughout the country, and this and the climatic conditions are very favorable to a Park.

Resolutions Relating to Forest Reserve.—That the need of such a reserve as has been described above is appreciated by men of all stations, is shown by the many resolutions that have been passed, of which the following have been acted upon during the past year:

In March, 1906, a Forestry Congress was called at Charlotte, N. C., to which delegates were sent representing the States interested in the preservation of the Appalachian forests. Governor R. B. Glenn was chairman of this meeting. At this meeting on March 3d the following resolutions were passed:

"*Resolved,* That the governments of each of the States interested in the perpetuation of the Appalachian forests be urged to appoint a committee of three to

> arrange for organizing State forestry associations to secure National action in behalf of local forest developments, and the appointment of State foresters.
>
> "*Second,* That the chairman of this meeting request the Governors of Virginia, West Virginia, Pennsylvania, Maryland, Tennessee, North and South Carolina, Georgia, Alabama, and each of the New England States, to coöperate with himself in appointing five delegates from each of these States to meet in Washington, at a date to be fixed by the chairman, to urge the passage of the bill now pending in Congress looking to the establishment and maintenance of forest reserves in the Appalachian and White mountains.
>
> "*Third,* That the Senators and Representatives in Congress from the States adjacent to Appalachian regions be earnestly urged to do everything in their power to secure the passage of these bills."

Pursuant to the second resolution, Governor Glenn appointed Mr. Henry E. Fries of Winston-Salem, Mr. F. R. Hewitt of Asheville, of the Geological Survey Board, and the State Geologist, among the delegates to represent North Carolina at the meeting to be held in Washington. This delegation met the Agricultural Committee of the House on April 24 and 25, 1906. Governor Glenn presided over this delegation, and made a very strong and eloquent speech to the committee in favor of the formation of the Appalachian and White Mountain Forest Reserves.

At a meeting of the American Cotton Manufacturers' Association held at Asheville May 16, 1906, the following resolutions were passed:

> "*Resolved,* That the members of this association urge upon their Representatives in Congress to give their earnest and lively support to the bill (Senate Bill No. 4953) now before Congress for the establishment of these forest reserves; and, further,
>
> "*Resolved,* That it is the opinion of this association that the organization of State forestry associations, especially in those States containing forests of large economic importance, will be of material assistance in the preservation and perpetuation of a State's forests, and that such organizations should be made as rapidly as possible."

The State Geologist desires to call the attention of the General Assembly to the fact that the bill now before Congress for the establishment of the Appalachian and White Mountain Forest Reserves has passed the Senate and been favorably recommended by the House Committee on Agriculture, and would earnestly urge that the present Legislature adopt resolutions to be presented to the House of Representatives requesting that the bill be allowed to be brought up for discussion during the present session of Congress. In this connection the State Geologist has, with the American Forestry Association, obtained a memorial or petition to be sent to the members of the House of Representatives from the Southern Appalachian States, which will be signed by the Governors and other State officials and prominent professional and business men. The following is the resolution that is being signed:

To the Members of the House of Representatives from the Southern Appalachian States.

GENTLEMEN:—In regard to the bill now before the House of Representatives for the establishment of the two forest reserves in the East to be known as the Appalachian and White Mountain Forest Reserves, we, the undersigned, request your earnest efforts in its behalf, believing that the passage of this bill will be of infinite value to the various States in New England and the Southern Appalachians. We, therefore, desire your personal influence in securing its passage at this short session, as it has already passed the Senate and been unanimously recommended to the House by the Committee on Agriculture.

It is the opinion of those who have studied this question that a bill creating these forest reserves must ultimately be passed, and as any delayed action will necessarily increase the cost to the Government of the formation of these forest reserves, it is economy on the part of Congress to pass the present bill. The main reason, however, for immediate action is to prevent all the work hitherto accomplished from having to be done over, and to prevent further denudation of the mountain slopes, which, if not checked, will go on more rapidly, causing irreparable damage not only to the water-powers of the country both North and South, but also to farm lands, roads, railroads, etc.

We, therefore, request that you give this matter serious and immediate consideration, and individually and collectively bring this to the attention of the Speaker and support the bill on the floor of the House.

Very respectfully,

This request has already been signed by the Governors and other State officials of Alabama, Georgia, Maryland and North Carolina. A similar request has been signed by all the Governors of New England and other prominent men of those States.

STATE SWAMP LANDS.

Another line of work that has been taken up by the Survey has been an examination of portions of the swamp lands belonging to the State, and it has been thought that the report of this work, which was done by Mr. W. W. Ashe, should be published as a part of the present Biennial Report of the State Geologist.

REPORT ON AN EXAMINATION OF CERTAIN SWAMP LANDS BELONGING TO THE STATE.

BY W. W. ASHE, FORESTER.

An examination of the most promising portions of the swamp timber lands belonging to the State, and under the control of the North Carolina State Board of Education, has been made under the supervision of the United States Bureau of Forestry, at the request of the North Carolina Geological and Economic Survey, in order to ascertain the advisability of placing them under forest management and simply selling the trees, and also to determine the value of these lands and what portions it would be best to sell outright.

This land, which is held for the benefit of the public school fund of the State, embraces about 500,000 acres, all of which is situated in the Atlantic Coastal Plain region and within 80 miles of the coast.

It is not in any single body, but includes more than 15 different tracts from a few hundred acres to more than 110,000 acres in area.

The North Carolina Geological Survey, in consultation with Mr. J. Y. Joyner, Superintendent of Public Instruction, and Mr. Duckett, Chief Clerk to the Board of Education, decided upon three areas lying in different portions of the coastal plain, as the most promising, and these were examined. Since so much of the valuable timber is situated near the edges of the swamp, especially the larger ones, the examination was confined to those areas which had been surveyed, the boundary-lines of which were known at least in part, and where there were fewest counter-claims. The tracts chosen for examination were:

Angola Bay, in Pender and Duplin counties, embracing, exclusive of interior holdings, 44,000 acres.

Open grounds of Carteret County, with an area of 110,000 acres.

Newport Pocosin in Craven County, having an area of 8,000 acres.

The results of the examination of these tracts of timber lands are embodied in the following pages, each tract being taken up separately:

Angola Bay.—The Board of Education has recently had two offers to purchase this swamp, and its sale has been under consideration by the Board. For this reason it was considered advisable to examine it first. The Board also had a report upon the amount, condition, and location of the timber upon it made by an experienced pine-timber estimator, Mr. Sylvester Peel. This report, to which access was given, was found to be accurate on the points it considered, and proved of great service.

This swamp is situated about thirty miles north of Wilmington, N. C. The Northeast Cape Fear River flows for ten miles within a mile of the western limits of the Board's holdings. This river is open to steamboat navigation. Holly Shelter Creek, a tributary of Northeast River, which follows closely the southern and eastern boundaries for about fourteen miles, is large enough for rafting for ten miles during winter and spring. The Wilmington branch of the Atlantic Coast Line Railroad is from six to ten miles west of the swamp. This and the river furnish ample facilities for transportation. The swamp is ten miles long, northwest and southeast, and seven miles wide east and west.

The surface is nearly level. The highest point at the northwest corner is only about forty feet above mean tide-water level at Crooms' bridge on the Northeast River, and those portions along the southeast side of the swamp are only ten to fifteen feet above mean water level in the streams. There is a gradual and almost uniform fall of three to six feet to the mile. A chain of small sand ridges from one to three feet above the general level of the swamp extends from near the center of the swamp to the southeastern edge.

The soil of the entire State holdings, except such of the sandy ridges as have not been sold, is very uniform in character. It consists of either pure peat, formed from sphagnum or sphagnum-like mosses, or of a mixture of moss, peat, and other organic matter formed by the decay of leaves, twigs, and roots of ericaceous shrubs, leaves of bay trees, and a small amount of grass and pine leaves. Only around the edges of the swamp is there any considerable amount of inorganic material in the soil, and this consists almost entirely of fine sand. This peaty soil is from three to eleven feet deep and is underlaid by sand or sandy loams. When the proportion of sand becomes large, probably more than 30 per cent., and the land is so situated that it can be drained and sweetened, it makes fair farming land. Such land, however, is situated only around the margins of the swamp, and has largely passed into the possession of private owners. Lumps of soil, selected at different places in this swamp, and also from the other tracts examined, and air-dried for two weeks, gave, when moistened, an acid reaction on litmus paper. Their acidity is, undoubtedly, too great for the growth of staple crops or for the growth of most trees.

In spite of a rainfall of nearly sixty inches a year, the sponginess of the soils and their imperfect drainage, they become very dry and inflammable during dry seasons, in the spring as well as summer and fall. Places were noticed where holes three and four feet deep had been burned, some of them ten and twenty feet wide. When a fire occurs during a dry period it is seldom that the entire soil on the burned area is not consumed to a depth of from six inches to a foot or more. A fire which took place in September, 1904, burned over between three and four thousand acres. Of this more than one thousand acres was burned to an average depth of more than eighteen inches, and there were thousands of holes between knee and waist deep. On the other hand, on account of the poor drainage and sponginess the soil, during winter, and usually during spring, becomes extremely wet, and is often flooded to a depth of six inches or more, which makes walking very difficult or even impossible on account of the miring and bogginess. Around the edges of the swamp and bordering the larger streams, where the drainage is better, or where there is a large intermixture of sand, or the peaty deposit is not so deep, the soil is firmer and more compact. This condition is usually indicated by a growth of cane, and is favorable to the growth of pond pine.

The soil becomes less compact and the drainage poorer as the center of the swamp is approached. Near the center is an area of 2,000 or more acres, the soil of which trembles at each step. A public road was built through the swamp about twenty years ago. It was deeply ditched in each side to drain it, and these ditches likewise drain a narrow strip of land on each side of the road. It has no perceptible effect upon the growth of the pine timber contiguous to it, although an improved condition is marked by the cane which has appeared in small patches.

Timber.—The only tree of commercial importance on the three tracts examined is the pond pine. Intimately associated with it are the bays: the hull bay, which forms more than one-half of the arborescent and subarboreal growth other than the pine, the sweet or red bay, which is frequent, and the white bay, which occurs as single scattered specimens or forms nearly pure clumps from a few square feet to several acres in extent. The bays are vigorous sprouters and early seeders, and where fire is absent for a few years, form on most of the wetter soil, which is not too peaty, dense, almost impenetrable thickets. They grow rapidly in height, but have no commercial value, and would seriously interfere with an extension of the distribution of the pine, although in many places the pine seems to have no difficulty in holding its own.

Along some of the larger streams, which have cut channels to the sandy subsoil, are a few small cypress, the timber of which is inferior in quality, associated with small black-gum and red maple. The amount of such growth is insignificant and need not be considered.

There were reported to be a few acres of white cedar (juniper), but not a single specimen was seen on the Board of Education's land during this examination.

Distribution of Timber.—The merchantable timber is confined to a strip one-half to one mile wide on the west, south, and southeast sides of the tract, and lying immediately along the edge of the swamp. On portions of the southern edge and along the entire northern edge of swamp the adverse holdings extend far enough into the swamp to include all the merchantable timber. The farther the timber is situated from the edge of the swamp the poorer is its quality and the smaller its size. On the interior of the swamp the merchantable timber is confined to occasional clumps or groups of trees, often at great distances apart. The merchantable timber occupies between 6,000 and 7,000 acres. Peel estimates it at 18,000,000 feet board measure; evidently a liberal figure, on account of the large proportion of defective timber.

About two miles west of the center of the area is a treeless moor of 2,000 or 3,000 acres, covered only with a low growth of bitterbush, gallberry, cyrilla, and greenbrier. This growth forms the ground cover of the entire swamp, except on well-drained or firm-soiled areas, which are occupied by cane, and areas where it is crowded out by a dense growth of bays or a very heavy stand of pine.

Under the best conditions observed on any of the State lands where there is a firm, comparatively well-drained soil, this tree reached a height of 60 to 70 feet, and a diameter of 16 inches to 18 inches breast-high. Trees 12 inches in diameter breast-high, average about 90 years old. A thrifty young tree, growing under slightly better conditions than the average, had, at 58 years of age, a diameter of 8 inches breast-high and a height of 60 feet.

The pine in the interior of the swamp is very scrubby, seldom more than 25 to 30 feet in height, and rarely exceeding 10 inches in diameter. Trees 35 feet high and 10 inches in diameter breast-high, two miles in the interior, are more than 100 years old. It is possible that the fires, which occur from three to ten years apart, are partly responsible for this slow rate of growth, for the growth is irregular as well as slow, numerous bands of very slow growth alternating with much wider rings. While the rate of diameter growth is more rapid during the first two decades than subsequently, after that there seems to be but a slight decline in the rate, except when influenced by the irregular growth noted above. A large proportion of the trees above 12 inches in diameter are defective or unsound, either in the first or second log. This is indicated by large knot-holes or punk. A count showed fourteen unsound trees out of twenty-six trees, above 10 inches in diameter breast-high. While the conditions become very favorable for tree growth in the interior of the swamp, it is possible that if the fires could be checked, a far larger area might produce trees of merchantable size. Undoubtedly, a large number of these scrubby pines are stool sprouts from fire-killed saplings, and it is possible that all of the pines in the interior of the swamp may be such fire-sprouts. Many were probably killed back several times before they became large enough to escape injury.

Since no attempt was made to prepare a working plan for this tract, no count was made of the exact number of trees in the size classes, but notes were made at frequent and regular intervals of the number of saplings, poles, and standards to the acre, especially when it was evident that the soil was good and capable of producing timber large enough for saw-logs. The number of young trees from 8 to 12 inches in diameter breast-high on good soil is very large, probably twice the number of trees above 12 inches. The distribution of the size classes very irregular, on account of even-aged stands following fires and the great intolerance of the pond pine. While there is generally more or less young timber mixed with old stands, it is usually in clumps or groups of a few trees. There are sometimes large areas of approximately even-aged young timber which have come up after a fire. An area of saplings was noted 5 to 7 feet in height and from 300 to 500 to the acre extending for more than a mile.

There is an average of at least 12, and probably nearer 20 sound trees from 8 to 12 inches in diameter breast-high to the acre on the

6,000 acres capable of producing merchantable timber. The increase in diameter is slightly less than one inch during a decade. The poor diameter-growth, accompanied with the low height, results in very slight annual accretion. If placed at 50 feet, board measure, to the acre a year for the 6,000 acres of best quality, the rest of the tract regarded as non-productive, after the sale of the merchantable timber above 12 inches now standing, the tract would have a value, based on its earning power, of $12,000, or $2 per acre for the productive portion. This is on the basis of stumpage at $2 a thousand feet, board measure, the present price for this grade of timber, and neglects entirely taxes, from which this land is exempt. On account of the large portion of the tract which is waste land, the timber now mature will sell for almost, if not fully, as much as the land and timber together. If fire can be prevented during and immediately after lumbering, and the tract subsequently afforded protection from fire, the earning capacity of the tract and its value as an investment can be largely increased. If swept by a heavy fire while the dry tops are on the ground and the soil burned over the entire swamp, as it has already been burned in places, the entire earning power will be destroyed for a great many years.

Reproduction is excellent, 1 and 2-year-old seedlings are very common, not only immediately around seed-bearing trees, but on recent burns, at distances of 100 yards or more from seed trees.

The Open Ground of Carteret County.—The general condition of the tract is similar to that of Angola Bay. The topography is the same. The soils are peaty, and the interior is an open, treeless, peat bog, with only a growth of low ericaceous shrubs. Good timber occupies apparently not more than one-tenth of the 110,000 acres; scrubby pine growth on the inner edge of the peat bog covers perhaps 50,000 to 60,000 acres, while there are about 40,000 acres of open ground in the center of the tract. This estimate of the relative proportion of each is based on statements secured from surveyors and persons living near the land. A trip was also made through the tract at its longest part.

The pond pine is the only tree which has any commercial value, known to occur on the Board of Education's land, as the several bodies of white cedar and gum swamps are claimed by others.

The earning power of this tract, considering its large area, is very small. Stumpage has a lower value on account of the scattered character of the timber. Conditions are thus most unfavorable for profitable management.

Protection from fire will be extremely difficult unless the numerous adjoining properties, which form a narrow belt lying between the tract and the water-front, are acquired and managed in connection with it.

Newport Pocosin.—This is a small tract containing only 8,000 acres, and was reported by Peel to be "well timbered." The conditions are in nowise different from those of Angola Bay, as the soil is peaty and the pond pine the only tree of value. On account of the small area of this tract, the good timber around the margin forms a much larger proportion of the entire area. It is crossed at one end by the Atlantic and North Carolina Railroad.

This tract presents a good opportunity for the application of systematic management to the pond pine. The different-sized classes are well represented, and seedlings are abundant. It is frequently burned, but apparently not so severely as Angola Bay. The entire area was slightly burned this fall.

Holly Shelter Swamp has an area of 60,000 acres. It is situated near Angola Bay, and residents state that it had the same conditions as Angola Bay.

It should be mentioned here that a large part of the soil of these swamps is situated for the growth of white cedar. On account of fires, to which it is extremely sensitive, it could not be introduced unless they could be checked.

It should also be mentioned that there is a probable asset in these tracts in the hunting privilege, since they are all well stocked with deer and bear.

Recommendations.—It is believed that as the bulk of these swamp lands offer no inducements to management, their sale is advisable, provided they can be sold. By the exclusion of fire, by draining, and by planting cedar, large areas might be made productive eventually; but the great danger from fire, the cost of drainage, and the exceedingly doubtful character of the returns from such an investment make it impracticable at present. The case is different, however, as regards the areas timbered with pond pine. It is not a good policy to sell the lands at the prices now offered, which are often less than the stumpage value of the merchantable timber. These lands should be retained and the pond pine above 12 inches sold at $2 per thousand feet, board measure. Trees below 12 inches should be left, as they will furnish another crop in from 20 to 30 years. Fire should be excluded as far as possible, and in selling timber the contract should provide for this, as well as for the leaving of the smaller trees and their protection during lumbering.

Forestry Problems Along the Banks.—Problems of considerable interest have recently come up regarding the preservation of the small areas of forests that still remain on a few sections of the Banks, and of the reforestation of certain other sections. A definite plan of action is now being outlined in regard to these problems and the work will be taken up in coöperation with the United States Bureau of Forestry. This work has been under consideration for some time, and facts regarding the conditions existing along the Banks have been collected partly by Prof. Collier Cobb, in connection with his work on the Sand-Dunes and Reefs of Eastern North Carolina, and Mr. I. F. Lewis, of Johns Hopkins University, Baltimore, and Raleigh, N. C., who has spent two summers at work on the Banks near Beaufort, N. C. They have made some notes regarding the conditions as they were and now exist on Shackleford Banks, extending from Cape Lookout southwestward about eight miles, to Beaufort Inlet, which are embodied in the following paragraphs:

Shackleford Bank extends from Cape Lookout southwestward about eight miles to Beaufort Inlet, and is from a half to three-quarters of a mile broad. The whole Bank was, within the memory of the older inhabitants, heavily wooded over its entire area. Owing, however, to cutting of the timber for firewood and lumber, the sand of the beach began to drift in on the forest somewhere near 1840. At this time the beach was higher than the forest on the sound side. The beach is described by Mr. Torrey Moore, an inhabitant of the Bank since 1828, as "flattening out on the woods," and so killing the trees. At the present date the eastern end of the Bank is completely "sanded over." The original forest is represented only by several clumps or "islands" of live-oak, which happened to be hardy enough to withstand the drifting sand. Near the western end of the Bank, about two miles of this forest land still remains, though it is rapidly being encroached upon by the advancing sand. Along the seaward side of this strip the beach, originally narrow, has broadened to a quarter of a mile or more, destroying the forest as the sand moved toward the sound. The sand is encroaching on the forest with greater rapidity as the increased breadth of the beach gives more surface for the wind to take up the dry particles and blow them over on the forest.

The forest here is made up chiefly of live-oak and red cedar, with the red mulberry, holly, water beech (Carpinus), and red bay (Persea) occurring commonly. The trees are not large, but are densely massed, and serve to prevent the winter storms from sweeping over the Bank. Cutting of timber was once a common practice, but is no longer so, for the reason that the islanders realize that their only protection from storms lies in the forests themselves. The trees are still sometimes used for firewood by the natives.

The inhabitants of the island live on the side of the Bank near the sound, and make their living partly by fishing and partly by gardening. The soil is a deep and mellow loam, suitable for most vegetables grown in this country. The principal plants now under cultivation are figs, tomatoes, sweet and Irish potatoes, cabbage, turnips, beans, peas, watermelons and cantaloupes. If the drifting sand is allowed to advance much farther toward the sound, these gardens must be abandoned and the living of the inhabitants must become very precarious.

In the woods on the western end of Shackleford are a considerable number of ponies, cattle, sheep and goats. Sheriff Hancock of Carteret County estimates the numbers from Cape Lookout west as follows: Three hundred ponies, 500 sheep, 250 cattle, 300 goats. Of course, the existence of this live-stock depends on the preservation of the forests.

A more important, though less immediate, reason for checking the sand drift lies in its effect on the channels and fisheries of the sounds. Where the once wooded Bank has become a sandy desert, the sand blown by the wind has filled in or is filling in the channel of Core Sound. Wherever the woods are still in existence, the deep water extends up to the Bank, but where the woods have been exterminated, the channel near the Bank has filled up, being now only one or two feet deep at low water. This in itself is not of great importance for navigation so long as other channels near the mainland can be kept open. However, as the sand drifts in, these will gradually become shallower until, probably within the course of a few decades, the waterway between Bogue and Pamlico sounds will become closed. The effect of a filling in of the channels would be disastrous to the fishing industry at this point. The enormous stream of mullet and other fish now coming through Core Sound from Pamlico would be diverted to some other outlet, and fishing would cease to be a means of existence to the people of the region.

As an example of the effect on the people of the drifting sand, attention is called to Diamond City, a fishing village on the sound side of Shackleford Bank not far from Cape Lookout. When the forest covered this part of the Bank the villagers were prosperous, being sure of a good catch of fish and having productive gardens under cultivation. As the sand came over from the beach, the gardens were first destroyed, then the channels began filling in and the catch of fish fell off. Finally, as the sand spread out more and more, the winter storms began to sweep the Bank more and more completely, until, about 1903, conditions became such that the settlement was broken up, and the inhabitants, about four hundred in all, were compelled to move over to Harker's Island, near the mainland. Now Diamond City is visited only in the fall, when fishermen take up temporary quarters during part of the fishing season.

There is one element of the situation which, so far as is known, is different from the conditions where sandbinding work has been instituted, as, for instance, Cape Cod. The winds which cause the sands to move are from the south, blowing pretty constantly during the spring and summer, or growing season. The stronger northeast winds of winter have little effect on the sand. What effect they have consists in blowing the sand back towards the ocean. They are less effective as sand movers than the south winds of summer, partly because they blow less constantly and partly because their force is greatest when the sand is wet from winter rains and not easily to be moved. At any rate, the sand is moving north, carried so chiefly in the summer months, whereas at other points where conditions have been studied, it moves south and west, being blown by winter winds. This condition, which probably obtains along the South Atlantic and Gulf coast, causes the problem to be presented in a slightly different aspect from that usually considered, and serves to emphasize the desirability of experimental work at this point.

Early in January a preliminary survey will be made by one of the foresters of the United States Bureau of Forestry, and then a plan of work covering several seasons so as to insure the permanency of the results will be inaugurated by the North Carolina Geological and Economic Survey and the United States Bureau of Forestry. The plan will include not only the protection of the forests and farm lands already present, but also the reforestation of the barren portions. The results will be extremely valuable both from a practical and scientific point of view.

In order to carry on the forestry work efficiently and to accomplish the desired results, I would recommend a special appropriation of at least $3,000, to pay the salary and expenses of a forester, who would take charge of all the work relating to forestry.

MAGNETIC SURVEY.

In March, 1898, a magnetic survey was begun in North Carolina under the joint auspices of the United States Coast and Geodetic Survey and the North Carolina Geological Survey. The plan of work was the establishment of a true north and south line and the determination of the magnetic declination, dip and horizontal intensity, at every county-seat in the State. This work was continued until this was accomplished. In order to determine the changes in the declination the stations are now being re-occupied, and during the past two years eight stations have been re-occupied. One new station was established at Raleigh on the land of the Experiment Farm about two miles from the center of the city. It is 72.1 feet from the nearest corner of the house occupied by Mr. Jeffreys and 111.5 feet from the nearest corner of a vacant house to the southwest. It is marked by a post of Georgia marble 6 inches square. The following true bearings were determined:

From northeast edge of cross on Catholic church..........	1° 21.3	west of south.
From spire on glass turret of hospital....................	32° 46.7	east of south.
From southeast corner of Agricultural College............	42° 01.7	east of south.

The following magnetic observations were made during 1905 and 1906, and there is also given the earlier observations at these same points:

MAGNETIC OBSERVATIONS AT NORTH CAROLINA STATIONS.

Place.	County.	Date.	Declination West.		Observer.
			Degrees.	Minutes.	
Wadesboro	Anson	Jan. 6, 1904	0	11.7	F. M. Little.
Wadesboro	Anson	Oct. 21, 1904	0	8.5	F. M. Little.
Salisbury	Rowan	April 21, 1905	0	34.	W. H. Burger.
Halifax	Halifax	July 19, 1906	2	19.7	F. W. Reed.
New Bern	Craven	July 25, 1906	3	13.6	F. W. Reed.
Southport	Brunswick	July 27, 1906	2	14.	F. W. Reed.
Raleigh (Old Station)	Wake	Aug. 1, 1906	2	54.2	F. W. Reed.
Raleigh (New Station)	Wake	Aug. 2, 1906	2	21.8	F. W. Reed.
Chapel Hill	Orange	Aug. 6, 1906	1	54.	F. W. Reed.
Morganton	Burke	Aug. 8-10, 1906	0	38.9	F. W. Reed.

EARLIER OBSERVATIONS AT NORTH CAROLINA STATIONS.

Place.	County.	Date.	Declination West.		Observer.
			Degrees.	Minutes.	
Halifax	Halifax	April 29, 1899	2	0	J. D. Baylor.
New Bern	Craven	July 9, 1898	2	46.6	J. D. Baylor.
Southport	Brunswick	Aug. 5, 1898	1	50.4	J. D. Baylor.
Raleigh (Old)	Wake	June 10, 1899	2	27.1	J. D. Baylor.
Chapel Hill	Orange	Mch. 25, 1898	1	28.6	J. D. Baylor.
Morganton	Burke	Sept. 3, 1900	0	27.7	J. D. Baylor.

A complete list of declinations in North Carolina as observed at the county-seats are given in the report of the United States Coast and Geodetic Survey for 1898-1899 in a separate known as Appendix No. 9.

The following directions to surveyors concerning the use of the county meridian lines either for determining magnetic declination or for ascertaining the index errors of their instruments are given by the United States Coast and Geodetic Survey and should be carefully followed:

> "If the instrument used be mounted on a tripod, it should be carefully centered and leveled over the cross on top of the same monument—the 'reference' monument—over which observations were made in the magnetic survey and described in the descriptions of stations as published in this report. The monument to be sighted on is termed the 'range' monument.
>
> "Should the instrument used be mounted on a simple Jacob's staff, it can be placed in the meridian line as close to the 'reference' monument as possible and leveled.
>
> "A small rod should then be held in a vertical position over the cross in the top of the other monument—the 'range' monument. The compass needle is released and magnetic bearing of the small rod read. This should be done with a small

non-magnetic magnifying glass, and it should be repeated about ten times, disturbing the needle with a bit of iron and letting it come to rest before each reading. The mean of all these bearings should be taken as the magnetic declination west or east, as the case may be.

"In order to obtain the mean declination for the day (24 hours) these results should be obtained between 10:00 and 10:30 A. M., or about 6:00 P. M., local mean time. (See Table I of report referred to). The local mean time is obtained by subtracting from the railroad time four minutes for every degree of longitude the surveyor is west of the seventy-fifth meridian of longitude. No observations should be made during times of violent changes of the pointing of the magnetic needle, as, *e. g.*, during magnetic storms.

"Should the resulting declination differ essentially from the declination as obtained from the published value in the report referred to, it proves conclusively that the surveyor's instrument has an error, which should be gotten rid of as nearly as possible by putting the instrument and needle in good adjustment. Any difference still remaining after the surveyor has satisfied himself that his instrument is in first-class condition and in good adjustment should be duly allowed for and recorded by the surveyor."

FISHING INDUSTRIES.

During the past two years a great deal of work has been done by the Survey in connection with the fishing industries of the State, and in this work we have had the hearty coöperation of the United States Bureau of Fisheries. Special investigations have been made regarding the shad and herring fishing industries; and the cultivation of the oyster, clam and terrapin. These investigations have shown that it is absolutely necessary that the State take some measures to protect its fishing industries of all kinds in order to prevent the total extermination of certain of these fish and the destruction of certain fishing industries that are of very great value to the State. In consequence of these investigations, at the suggestion of the State Geologist, the Governor, as chairman of the Geological and Economic Survey Board, appointed a committee of representative men of eastern North Carolina, which met at Morehead City during September and took up a thorough discussion of the situation, and suggested certain measures which they believe will insure protection of our fishing industries and prevent the extermination of any of our fish or a decrease in any of the fishing industries. This committee also suggested such legislation as in their opinion would result in the commercial cultivation of the oyster, clam and terrapin. The deliberations of this committee have been published as Economic Paper No. 13. The State Geologist would call especial attention to the suggestions of this committee regarding the organization of a Fish Commission and a Shell-fish Commission for North Carolina as given on pages 14 and 44 of the report; to general legislation as recommended on pages 39 to 42, particularly as it refers to Early Closing Season for Shad and Herring; to the general laws regarding terrapin given on page 43; and to the cultivation of the oyster and clam as given on pages 67 to 71.

If the General Assembly will provide for a Fish Commission for North Carolina and give this Commission the authority to enforce all laws relating to the fishing industry, it will have taken a long step forward in the protection and perpetuation of the State's fishing industries. The products of the waters of the State belong to the State and not to the individual, and, therefore, the State has a right and should exercise this right to prevent the wholesale or total destruction of industries that are of great value; and of the total elimination of certain fishes within its waters by restricting at all places the fishing season and limiting, as far as possible, the amount of apparatus fished. While such restrictions may, for the time being, prove a hardship for a few individuals, yet in the end it will mean a large increase in the fishing industries, and will, therefore, mean a larger revenue to the individual and through him to the State.

Investigations have been carried on during the past two years by Messrs. R. E. Coker, Biologist of the Survey, and H. D. Aller, of the U. S. Bureau of Fisheries, on oyster culture in North Carolina. The results of these investigations have shown that the cultivation of the oyster in many of the waters of eastern North Carolina is practicable and profitable. One report has already been published on this subject and the text for another is now being edited.

Investigations have been carried on by Dr. R. E. Coker on the natural history and cultivation of the diamond-back terrapin, and the results have been published in a report known as Bulletin No. 14. This work was also done in coöperation with the United States Bureau of Fisheries. The condition of the shad and herring industries was investigated by Mr. John N. Cobb, of the United States Bureau of Fisheries, and the results of the investigation have been published in Economic Paper No. 12. In connection with this work, a series of maps were prepared of Pamlico and Albemarle sounds and tributaries, together with the Cape Fear River districts, showing the location of all nets used in fishing for shad and herring during 1906. As these maps were prepared from the latest charts of the United States Coast and Geodetic Survey, they will make very useful base maps for further work in regard to the various fishing industries of the State.

Another work that has been finished during the past year which will be of value and interest to all North Carolina is a volume on the Fishes of North Carolina. This volume is now in press and should be ready for distribution within the next two months. It gives a detailed description of every fish that has been found in North Carolina, and in most cases figures are given of each. This work has been done for the Survey by Dr. H. M. Smith of the U. S. Bureau of Fisheries.

PUBLICATIONS.

During 1905 and 1906 the following publications have been issued by the North Carolina Geological and Economic Survey which embody the results of the investigations briefly outlined above, and to which references have been made:

VOLUMES.

No. 1. Corundum and the Peridotites of Western North Carolina and other economic minerals associated with these rocks, by Joseph Hyde Pratt and Joseph Volney Lewis, 464 pages, 45 plates.

BULLETINS.

No. 2. Building and Ornamental Stones of North Carolina, by T. L. Watson and F. B. Laney in collaboration with Dr. George P. Merrill, 283 pages, 22 plates.

No. 14. On the Natural History and Cultivation of the Diamond-back Terrapin, by R. E. Coker, 70 pages and 23 plates.

ECONOMIC PAPERS.

No. 9. Mining Industry of North Carolina During 1904, by Joseph Hyde Pratt, 95 pages.

No. 10. Oyster Culture in North Carolina, by R. E. Coker, 39 pages.

No. 11. Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, — pages.

No. 12. Investigations Relative to the Shad Fisheries of North Carolina, by John N. Cobb, 42 pages, 7 plates.

No. 13. Report of Committee Appointed by Governor R. B. Glenn to Investigate the Fishing Industries in North Carolina, compiled by Joseph Hyde Pratt, 75 pages.

GOOD ROADS CIRCULARS.

Eleven of these circulars have been issued during the past two years and distributed throughout the State. They have taken up all sorts of questions pertinent to the subject of good roads. Some of these have laid special emphasis on the issuing of bonds for the construction of good roads. Circular No. 40 took up especially the relation of public roads to immigration.

The following reports are now in press and should be ready for distribution by March 1, 1907:

VOLUMES.

No. 11. Fish and Fisheries of North Carolina, by H. M. Smith, a volume of about 500 pages.

BULLETINS.

No. 15. Gems and Precious Stones of North Carolina, by George F. Kunz, about 11 pages.

The following reports are in preparation:

VOLUMES.

Mineral Resources of North Carolina, by Joseph Hyde Pratt. This will make a volume of about 400 to 450 pages.

Mica and the Pegmatites of North Carolina, by Joseph Hyde Pratt and D. B. Sterrett.

The Cretaceous Formations of North Carolina, by E. W. Berry.

BULLETINS.

Mineral Waters of North Carolina, by F. P. Venable and Joseph Hyde Pratt.
The Copper Deposits of North Carolina, by Joseph Hyde Pratt and F. B. Laney.
The Loblolly Pine in Eastern North Carolina, by W. W. Ashe.
Shade Trees of North Carolina, by W. W. Ashe.
Artesian Water Supply in North Carolina, by L. S. Stephenson and E. W. Berry.
Sand Dunes and Reefs of North Carolina, by Collier Cobb.

ECONOMIC PAPERS.

Low Grade Gold Ores of North Carolina, by A. A. Steel.
Mining Industry in North Carolina for 1906, by Joseph Hyde Pratt.

CO-OPERATIVE WORK WITH U. S. GOVERNMENT SURVEYS AND BUREAUS.

Under section 9 of the act creating the Geological and Economic Survey, the State Geologist, with the approval of the Geological Board, is authorized to arrange for and accept such aid and coöperation from the several United States Government Bureaus and other sources as may assist in completing the topographic surveys of the State and in carrying out other provisions of this act.

Under this section, coöperative work has been carried on with the United States Bureau of Fisheries in connection with the investigations relating to fin-fish and shell-fish industries of the State. They have been most liberal in their coöperation with us, realizing that the work that is being done by the Geological and Economic Survey is of the utmost importance to the State and is also of great importance to the general fishing industries of the United States. They have also signified their willingness to coöperate with us during the coming two years along similar lines as during the past two years. This will mean that the State will be able to carry on these investigations relating to the cultivation of the oyster and clam which it would be almost impossible for it to do without this coöperation, on account of the very large expense. This work will be of inestimable assistance to the Fish and Shell-fish Commissioners in their investigations relating to the fishing industries.

The coöperative work with the United States Geological Survey has been of very large value to the State, and has included topographic work and investigations relating to the mica deposits, the black sand investigations, general investigations relating to geology and the investigations of the artesian water supplies.

The Division of Public Roads of the U. S. Department of Agriculture has coöperated with the State Survey in obtaining statistics relating to the public roads of North Carolina, and has coöperated with several of the counties in the construction of sand-clay roads.

The Bureau of Forestry of the U. S. Department of Agriculture has also coöperated with the State Survey in connection with its examination of some of the swamp lands belonging to the State in eastern North Carolina, and in its investigations relating to the Appalachian Forest Reserve. It is now coöperating with the State Survey in the investigation of the banks of eastern North Carolina.

The United States Coast and Geodetic Survey is now re-occupying many of the meridian stations established in the counties of this State, and will continue this coöperation until all have been re-occupied.

The Geological and Economic Survey has also coöperated with several companies and individuals within the State in furnishing to them members of the Geological Survey staff for making special geological examinations of particular tracts of land. In most cases the cost of this work has been borne largely by the company or individual, the Geological Survey having the privilege of using all data and information collected by its men in any of its reports.

OFFICE WORK.

The office work of the Survey has been carried on by the State Geologist, assisted by Mr. F. B. Laney, Assistant Geologist; Miss H. M. Berry, Clerk and Stenographer, with Mr. R. H. Sykes, Miss Caro Gray and Mr. John Berry as temporary assistants. A considerable portion of the office work of the State Geologist has been the editing of the reports referred to above and the correction of the proof of these as they were going through the press. The correspondence requires a great deal of time of the State Geologist and his assistants, and letters are constantly being received requesting information regarding the localities of different minerals, statistics regarding their production, the value of mineral properties, methods for developing and mining the same, markets for mineral products; information regarding water-powers, artesian wells and mineral waters; information regarding forests, available tracts of forest lands, different varieties of timber, etc.; the construction of public roads and localities for obtaining materials for road construction; the oyster and fish industries, etc. During the past two years approximately six thousand letters have been written at the Survey office besides the circular-letters that have been sent out asking for and giving general information regarding certain subjects.

The value of the work of the Geological and Economic Survey is perhaps best illustrated in the enormous correspondence that is received at the office asking for information regarding all the subjects that have been mentioned above and which can be satisfactorily answered on account of the investigations that have been made. This has resulted in bringing into the State a great deal of capital for the development of the natural resources of the State, and it has also been the means of bringing many people into the State who have become permanent citizens.

The following statement will show the receipts and expenditures of the Geological and Economic Survey for the two years ending November 30, 1906, grouped according to the subjects investigated during this time. These are arranged separately for each of the two years.

DECEMBER 1, 1904, TO NOVEMBER 30, 1905.

RECEIPTS.

Balance on hand		$ 2.48
Appropriation		10,000.00

DISBURSEMENTS.

Good roads investigations	$ 1,455.28	
General mineral investigations	1,519.03	
Mining industry investigations	600.00	
Building stone investigations	1,690.95	
Corundum investigations	1,050.00	
Oyster and fish investigations	462.23	
Water-power investigations	360.00	
Forestry investigations	637.00	
Geological Board expenses	163.56	
Office expenses	326.93	
Clerical work	1,585.00	
Miscellaneous	52.50	
	$ 10,002.48	$ 10,002.48

DECEMBER 1, 1905, TO NOVEMBER 30, 1906.

RECEIPTS.

Appropriation		$ 10,000.00
Sale of typewriter		25.00
Coöperative fund		162.73

DISBURSEMENTS.

Good roads investigations	$ 500.00	
General mineral investigations	666.92	
Mining industry investigations	600.00	
Building stone investigations	663.33	
Gold investigations	507.54	
Copper investigations	790.07	
Black sands investigations	219.52	
Sand dune and reef investigations	31.70	
Mica investigations	546.80	
Oyster and fish investigations	1,243.77	
Artesian well investigations	747.77	
Topographic work	120.50	
Forestry investigations	291.46	
Geological Board expenses	259.00	
Office expenses	525.31	
Freight and express	321.72	
Clerical work	1,357.60	
Back accounts	160.75	
Miscellaneous	55.25	
Balance on hand	578.72	
	$ 10,187.73	$ 10,187.73

PUBLICATIONS

OF THE

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY.

BULLETINS.

1. Iron Ores of North Carolina, by Henry B. C. Nitze, 1893. 8°, 239 pp., 20 pl., and map. *Postage 10 cents.*

2. Building Stone in North Carolina, by T. L. Watson and F. B. Laney in collaboration with George P. Merrill, 1906. 8°, 283 pp., 32 pl., 2 figs. *Postage 25 cents. Cloth-bound copy 50 cents extra.*

3. Gold Deposits in North Carolina, by Henry B. C. Nitze and George B. Hanna, 1896. 8°, 196 pp., 14 pl., and map. *Out of print.*

4. Road Material and Road Construction in North Carolina, by J. A. Holmes and William Cain, 1893. 8°, 88 pp. *Out of print.*

5. The Forests, Forest Lands and Forest Products of Eastern North Carolina, by W. W. Ashe, 1894. 8°, 128 pp., 5 pl. *Postage 5 cents.*

6. The Timber Trees of North Carolina, by Gifford Pinchot and W. W. Ashe, 1897. 8°, 227 pp., 22 pl. *Postage 10 cents.*

7. Forest Fires: Their Destructive Work, Causes and Prevention, by W. W. Ashe, 1895. 8°, 66 pp., 1 pl. *Postage 5 cents.*

8. Water-powers in North Carolina, by George F. Swain, Joseph A. Holmes and E. W. Myers, 1899. 8°, 362 pp., 16 pl. *Postage 16 cents.*

9. Monazite and Monazite Deposits in North Carolina, by Henry B. C. Nitze, 1895. 8°, 47 pp., 5 pl. *Postage 4 cents.*

10. Gold Mining in North Carolina and other Appalachian States, by Henry B. C. Nitze and A. J. Wilkins, 1897. 8°, 164 pp., 10 pl. *Postage 10 cents.*

11. Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. Volney Lewis, 1895. 8°, 107 pp., 6 pl. *Postage 4 cents.*

12. Drinking-water Supplies in North Carolina, by Joseph A. Holmes. *In preparation.*

13. Clay Deposits and Clay Industries in North Carolina, by Heinrich Reis, 1897. 8°, 157 pp., 12 pl. *Postage 10 cents.*

14. The Cultivation of the Diamond-back Terrapin, by R. E. Coker, 1906. 8°, 67 pp., 23 pl., 2 figs. *Postage 6 cents.*

15. Mineral Waters of North Carolina, by F. P. Venable. *In press.*

16. A List of Elevations in North Carolina, by J. A. Holmes and E. W. Myers. *In preparation.*

17. Historical Sketch of North Carolina Scientific and Economic Surveys; and Bibliography of North Carolina Geology, Mineralogy and Natural History, by J. A. Holmes and L. C. Glenn. *In preparation.*

18. Road Materials and Construction, by Joseph A. Holmes and William Cain. *In preparation.*

19. The Tin Deposits of the Carolinas, by Joseph Hyde Pratt and Douglass B. Sterrett, 1905. 8°, 64 pp., 8 figs. *Postage 4 cents.*

20. The Loblolly Pine in Eastern North Carolina, by W. W. Ashe. *In preparation.*

ECONOMIC PAPERS.

1. The Maple-Sugar Industry in Western North Carolina, by W. W. Ashe, 1897. 8°, 34 pp. *Postage 2 cents.*

2. Recent Road Legislation in North Carolina, by J. A. Holmes. *Out of print.*

3. Talc and Pyrophyllite Deposits in North Carolina, by Joseph Hyde Pratt, 1900. 8°, 29 pp., 2 maps. *Postage 2 cents.*

4. The Mining Industry in North Carolina During 1900, by Joseph Hyde Pratt, 1901. 8°, 36 pp., and map. *Postage 2 cents.*

5. Road Laws of North Carolina, by J. A. Holmes. *Out of print.*

6. The Mining Industry in North Carolina During 1901, by Joseph Hyde Pratt, 1902. 8°, 102 pp. *Postage 4 cents.*

7. Mining Industry in North Carolina During 1902, by Joseph Hyde Pratt, 1903. 8°, 27 pp. *Postage 2 cents.*

8. The Mining Industry in North Carolina During 1903, by Joseph Hyde Pratt, 1904. 8°, 74 pp. *Postage 4 cents.*

9. The Mining Industry in North Carolina During 1904, by Joseph Hyde Pratt, 1905. 8°, 95 pp. *Postage 4 cents.*

10. Oyster Culture in North Carolina, by Robert E. Coker, 1905. 8°, 39 pp. *Postage 2 cents.*

11. The Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, 1906.

12. Investigations Relative to the Shad Fisheries of North Carolina, by John N. Cobb, 1906. 8°, 74 pp., 8 maps. *Postage 6 cents.*

13. Report of Committee on Fisheries in North Carolina. Compiled by Joseph Hyde Pratt, 1906. 8°, 78 pp. *Postage 4 cents.*

REPORTS ON RESOURCES.

Vol. 1. Corundum and the Basic Magnesian Rocks in Western North Carolina, by Joseph Hyde Pratt and J. Volney Lewis, 1905. 8°, 464 pp., 44 pl., 35 figs. *Postage 32 cents. Cloth-bound copy 50 cents extra.*

Vol. 2. Fish and Fisheries in North Carolina, by H. M. Smith. *In press.*

Vol. 3. Miscellaneous Mineral Resources in North Carolina, by Joseph Hyde Pratt. *In preparation.*

Samples of any mineral found in the State may be sent to the office of the Geological and Economic Survey for identification, and the same will be classified free of charge. It must be understood, however, that NO ASSAYS, OR QUANTITATIVE DETERMINATIONS, WILL BE MADE. Samples should be in a lump form if possible, and marked plainly with name of sender outside of package, post-office address, etc.; a *letter* should accompany sample and *stamp* should be enclosed for reply.

These publications are mailed to libraries and to individuals who may desire information on any of the special subjects named, free of charge, except that in each case applicants for the reports should forward the amount of *postage* needed, as indicated above, for mailing the bulletins desired, to the *State Geologist, Chapel Hill, N. C.*

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